MAR 17 1931

Volume 5 MARCH 1931 Number 1

JOURNAL OF PALEONTOLOGY

A Publication of the Society of Economic Paleontologists and Mineralogists,
a Division of
The American Association of Petroleum Geologists

CONTENTS

The Gastropods of the St. Louis, Missouri, Pennsylvanian Outlier: *Aclisina and Streptacis* — *J. Brookes Knight* 1

New Permo-Pennsylvanian Fusulinidae from Northern Oklahoma — *John W. Skinner* 16

New Species of Chester Fossils — *A. H. Sutton and O. E. Wagner, Jr.* 23

A Miocene *Haliotis* from Southern California — *W. P. Woodring* 34

PALEONTOLOGICAL NOTES

Late Devonian Foraminifera from Iowa — *A. O. Thomas* 40

A Note on *Lepidocyclina hilli* Cushman — *T. Wayland Vaughan* 41

The Velasco-Mendez Contact in the Vicinity of the Ebano Field, Mexico — *Henry J. Morgan, Jr.* 42

Late Paleozoic Holothuroidea — *Carey Croneis* 47

Bairdia coryelli, a New Name for *B. ventricosa* Roth and Skinner — *Robert Roth and John Skinner* 48

METHODS AND TECHNIQUE

Illustrating Fossils — *G. Dallas Hanna* 49

SOCIETY RECORDS AND ACTIVITIES

Members of the Society of Economic Paleontologists and Mineralogists 69

AMONG PALEONTOLOGISTS 76

JOURNAL of PALEONTOLOGY

RAYMOND C. MOORE, EDITOR

ASSOCIATE EDITORS

JOSEPH A. CUSHMAN
Sharon, Massachusetts

JOHN B. REESIDE, JR.
Washington, D. C.

CARL O. DUNBAR
New Haven, Connecticut

T. WAYLAND VAUGHAN
La Jolla, California

G. DALLAS HANNA
San Francisco, California

WENDELL P. WOODRING
Pasadena, California

The Journal of Paleontology is published quarterly by the Society of Economic Paleontologists and Mineralogists, a division of The American Association of Petroleum Geologists. Numbers are issued in March, June, September and December.

The subscription price of the JOURNAL OF PALEONTOLOGY is $6.00 per year prepaid to addresses in the United States, Mexico, Cuba, Porto Rico, Panama Canal Zone, Republic of Panama, Dominican Republic, El Salvador, Bolivia, Colombia, Honduras, Nicaragua, Peru, Hawaiian Islands, Philippine Islands, Guam, Samoan Islands.

Single numbers, $2.00 each.

Postage is charged extra: For Canada, 20 cents on annual subscriptions (total $6.20), and for all other countries in the Postal Union, 40 cents on annual subscriptions (total $6.40).

Claims for non-receipt of preceding numbers of the JOURNAL must be sent to the secretary-treasurer within three months of the date of publication in order to be filled gratis.

The JOURNAL will furnish reprints at cost. Orders should accompany corrected galley proof.

Communications about the JOURNAL, subscriptions, rates, memberships, change of address, and advertising should be addressed to GAYLE SCOTT, Secretary-Treasurer, Texas Christian University, Fort Worth, Texas.

Communications in regard to manuscripts or purely editorial matters should be addressed to RAYMOND C. MOORE, Editor, University of Kansas, Lawrence, Kansas.

Published at Tulsa, Oklahoma

Entered as second-class matter at the Post Office at Fort Worth, Texas, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1923.

MID-WEST PTG. CO., TULSA, OKLA., U. S. A.

Volume 5 Number 1

JOURNAL OF PALEONTOLOGY

MARCH 1931

THE GASTROPODS OF THE ST. LOUIS, MISSOURI, PENNSYLVANIAN OUTLIER: *ACLISINA* AND *STREPTACIS*

J. BROOKES KNIGHT
Peabody Museum, Yale University, New Haven, Conn.

ABSTRACT

The genus *Aclisina* de Koninck is considered briefly, and the described species from American Pennsylvanian strata are reviewed. On the basis of the wide range of individual variation found in the large number of well preserved specimens studied, the seven specific names of recognizable forms are reduced to three.

The genus *Streptacis* Meek is discussed and for the first time defined. The close relationship of this genus to *Aclisina* is again pointed out.

The taxonomic position of *Aclisina* and *Streptacis* is discussed and it is shown that these genera are out of place in any of the several families to which the former has been referred, particular stress being placed on ontogeny. The new family, Streptacididae, is proposed to receive them, it being felt unwise to obscure their true characters by placing them in any of the established families.

Two species of *Aclisina* and one of *Streptacis* are redescribed and discussed. Three new species of *Streptacis* are described.

This is the second of a projected series of papers dealing with the gastropods of the St. Louis Pennsylvanian outlier and based on collections which contain specimens of numerous species in an unusually excellent state of preservation. For details of the stratigraphic section, register of localities, acknowledgments, and for other matters of a general nature the reader is referred to the preceding paper (1).

THE GENUS *ACLISINA*

Aclisina, the best known of the two closely related genera under consideration, was established by de Koninck in 1881 (2, p. 86), but it was not until Mrs. Longstaff (née Donald) re-studied the genus in 1898 (3) that it was placed upon a firm footing. Longstaff's characterization of the genus in that paper and again in another published in 1917 (4) is so minutely detailed and accurate that it leaves nothing to be added. Both papers are models well worth the study of any paleontologist

whether or not he has particular interest in the genus in question. Longstaff's generic diagnosis reads as follows (3, p. 48):

> Genus *Aclisina* de Koninck, emend. Donald. Shell small, elongated, conical, composed of numerous whorls. Apex blunt. Protoconch formed of about one smooth whorl, which is sometimes more or less detached from the highest whorl of the spire on the umbilical region. A faint rib indicates its junction with the conch, upon which the ornamentation begins almost immediately. Whorls convex, spirally striated. Sutures deep. Outer lip as indicated by the lines of growth sigmoidal, retreating from the suture and forming a wide shallow sinus, then arching prominently forward and retreating again below the base of the shell. Aperture ovoid. Columella nearly straight, slightly thickened. Inner lip reflected on the body whorl. Base convex. Umbilicus closed. The type of the genus is *A. pulchra* de Koninck.

Nine species referable to *Aclisina* have been described from the American Pennsylvanian strata, as follows:

Aclis minuta Stevens 1858 (5, p. 259)
Aclis robusta Stevens 1858 (5, p. 259)
Murchisonia minima Swallow 1858 (6, p. 203)
Turritella ?? *stevensana* Meek and Worthen 1866 (7, p. 382, pl. 27, fig. 8, 8a)
Turbonilla swallowiana Geinitz 1866 (8, p. 5, pl. 1, fig. 19)
Aclis ? *stevensoni* White, 1881 (9, p. 35, pl. 3, figs. 9a-b)
Aclisina formosa Mark 1912 (10, p. 314, pl. 16, fig. 7)
Aclisina conditi Mark 1912 (10, p. 314, pl. 16, figs. 8, 9)
Aclisina pumila Mark 1912 (10, p. 314, pl. 16, fig. 10)

Aclisina minuta (Stevens) and *A. minima* (Swallow) are inadequately described and have never been figured. They are entirely unrecognizable and the types are no longer in existence. The use of the names can only promote confusion. *A. robusta* (Stevens) was figured by Meek and Worthen (11, pl. 29, figs. 6-6a) from what appears to have been topotype material so that it can be regarded as fairly established. *A. formosa* Mark is placed by the present writer in the synonomy of *A. stevensana* (Meek & Worthen) and *A. stevensoni* (White) and *A. pumila* Mark in that of *A. robusta* (Stevens). *A. conditi* Mark is considered a synonym of *A. swallowiana* (Geinitz) as it seems to be merely a young form of that species. Thus there appear to be only three valid species of the genus as yet described from American Pennsylvanian strata: *A. robusta* (Stevens), *A. stevensana* (Meek and Worthen) and *A. swallowiana* (Geinitz).

The reference of four of the seven figured species to synonymy runs counter to expectation that the greater refinement in drawing specific lines which is greatly to be desired will increase the number of recognized species. Careful study of numerous beautifully preserved specimens shows such a wide range of completely intergrading individual variations in certain characters, variations which in the two species

studied cover the characters used in distinguishing the referred species, that there seems to be no other option. This will appear more specifically in the discussion following the description of species. And yet there may be more than two biological species represented in my collections. It seems quite possible that the range of variation in the shells of two or more really distinct species may so overlap as to simulate complete intergradation. We are dealing necessarily with shells alone, and are entirely unable to separate two such overlapping species on the basis of the shells.

The revolving threads, or lirae, of *Aclisina* can be divided into three groups. The first group is formed by those that appear on the upper surface of the whorl face. These are finer and weaker than those of the second group or, as in some species, are entirely suppressed. The second group is formed by those that occur on the sides of the whorls. These are commonly more strongly developed and conspicuous than those of the other two groups and are often the only ones observed. Those of the third group appear on the base and are typically more numerous and finer than those of the second group. To facilitate discussion and description these will be designated the superior, lateral and inferior groups, respectively.

There seems to be a tendency toward suppression of the revolving lirae. In some species this finds expression in the complete elimination of the superior lirae. In individuals of some species, for example *A. stevensana*, it is carried still farther by the weakening or elimination of some of the upper lateral lirae. With a few specimens only, these differences in the development of the lirae might be mistaken for specific characters, but I find such continuous variation from one extreme to the other, without any other correlatable differences, that it seems almost necessary to hold such differences as belonging within the field of individual variation.

THE GENUS *STREPTACIS*

The name *Streptacis* was proposed in a footnote by Meek in 1871 (12, p. 173) to replace the preoccupied name *Aciculina* Deshayes applied to a Tertiary and Recent genus to which Meek wished to refer a single Pennsylvanian species, *Streptacis whitfieldi* Meek. However, as Meek designated the Pennsylvanian species as the type and as it is not congeneric with the Tertiary and Recent forms, the name is technically in good standing. Meek did not give a generic diagnosis except as it

may be inferred from his description of the genotype. In supplying the lack I cannot do better than to follow the pattern of Longstaff's diagnosis of *Aclisina*.

Genus *Streptacis* Meek—Shell small, elongated, conical, composed of numerous whorls. Apex blunt. Protoconch formed of one smooth whorl which is sometimes more or less detached from the highest whorl of the spire on the umbilical region. A faint rib indicates its juncture with the conch. Whorls convex, sutures *shallow or* deep. *Ornamentation may be entirely lacking or may consist of rather weak transverse striae or costae. The latter in some species find expression as crenulations or a row of nodes just below the suture.* Outer lip, as indicated by the lines of growth, sigmoidal, retreating from the suture and forming a wide shallow sinus, then arching prominently forward and retreating again below the base of the shell. Aperture ovoid. Columella nearly straight, slightly thickened. Inner lip reflected on the body whorl. Base convex. Umbilicus closed. The genotype is *Streptacis whitfieldi* Meek.

In the above diagnosis only the italicized words differ from that of *Aclisina* and it is evident that the only distinction lies in the surface ornamentation. This seems to be a valid generic difference, but if it is not, Meek's name has priority of about ten years over that of de Koninck.

As Longstaff observed in *Aclisina* (4, p. 60) the nuclear disc varies in its position from species to species, lying flat in some, or tilted at various degrees in others, but it appears to be constant within each species.

Streptacis has been almost entirely neglected, perhaps largely because S. A. Miller (13, p. 427) seems to have confused it with *Streptaxis* Gray, an error that was continued by Weller who listed it in his bibliography (14, p. 611) as a synonym of that genus. *Streptaxis* was proposed by Gray in 1837 for some recent Helicidae from Africa. The names are partly of different derivation although differing by only one letter and the forms themselves are as different as any two groups of gastropods can be.

Only one species, *S. whitfieldi* Meek, has been referred to the genus and it has rarely been cited since. Meek and Worthen (11, p. 596, pl. 29, fig. 1a) cited and figured it once. Keyes cites it once (15, p. 241) and Mark gives it in several fossil lists (10). Besides the genotype and the new species to be considered in this paper, I would refer to the genus from the literature of the American Pennsylvanian only "*Loxonema*" *cerithiformis* Meek and Worthen (11, p. 379, pl. 31, figs. 13 a-c) although

Stevens' description of "*Chemnitzia*" *attenuata* (5, p. 259) indicates that it may also belong here. Of the better known foreign forms "*Loxonema*" *subconstrictum* de Koninck and "*Loxonema*" *constrictum* Martin as described and figured by de Koninck (2, pl. 6, figs. 19, 20, 23, 24) may find a place with it, as also other Mississippian species.

Aclisina and *Streptacis* are differentiated from each other on the basis of ornamentations. Both are separated from any known Paleozoic genera by their peculiar nuclei. Both are high-spired and have distinctive sinuosity of the outer lip. The revolving lirae of *Aclisina* are finer than in most murchisonids and the latter are further distinguished, of course, by the possession of a slit band. *Streptacis* is differentiated from similar smooth or weakly costate Pseudozygopleurae by the nucleus, by the more extended anterior margin of the aperture and by its somewhat thinner shell, which in some species is thicker on the base than on the sides, while the reverse is true in *Pseudozygopleura*. *Holopella* McCoy presumably has an entire aperture and only a slightly sinuous outer lip. However, aside from definitions, always of doubtful value when not reenforced by well described types, that genus is not well understood. To place it on a firm foundation will require a careful reworking of McCoy's specimens or, if they are no longer available, of authoritative topotype material.

THE FAMILY STREPTACIDIDAE KNIGHT

At one time or another *Aclisina* has been referred to various families of gastropods such as the Turbonidae, the Turritellidae, the Mathildiidae, the Cerithiidae, the Loxonematidae, and as a supposed synonym of *Holopella* McCoy to the Epitoniidae or Scalariidae. It is evident that its true relationships are problematical. Most of these families are Mesozoic or Tertiary, and since *Aclisina* is much older than other representatives of such families its inclusion in any of them carries the implication that it is the ancestral radicle from which the other genera were derived. This is a matter of some importance for a correct understanding of phylogeny. The genus has been mentioned also in connection with the Pyramidellidae but apparently it has not been formally referred to that family. This is somewhat surprising, as it seems to have more in common with that family than any other of the Paleozoic genera that are so often assigned to it. However, eliminating the Paleozoic and Mesozoic genera which are almost as doubtfully pyramidellids, there are no members of the family earlier than the Tertiary.

Longstaff points out the resemblance between the protoconch of *Aclisina* and that of *Promathildia* (3, p. 50) although she follows the weight of authority in placing the former with the Turritellidae. *Promathildia* seems to have a nucleus that is plano-spirally coiled for at least part of a turn and disposed at an angle to the succeeding whorls (16, p. 459), but aside from this one fact there is little in common between it and *Aclisina*. The fact that the Mathildiidae are quite ornate has less weight in excluding *Aclisina* from their ranks than the other fact that members of this family were certainly siphonate, which is almost as certainly not the case with *Aclisina*.

True heterostrophic nuclei arise in the Mesozoic and are found today in several major groups which are so far apart that they can have only a remote relationship. It follows that forms with heterostrophic nuclei must be derived ultimately from others with normal nuclei, and further, that this peculiar embryonic character, the significance of which is apparently unknown, appeared independently in several lines. It probably developed gradually, beginning in a plano-spirally coiled nucleus which at first lay flat on the succeeding whorls and next stood on edge. Both conditions are seen in *Aclisina* and *Streptacis*. The second only, appears in *Promathildia*. The final step would probably be the depression, as it were, of the center of the discoidal nucleus to effect what is essentially sinistral coiling in the then truly heterostrophic nucleus. *Mathildia* seems to have arrived at this stage, though apparently independently.

Since *Aclisina* has been assigned to these several families, usually without comment or justification, it seems hardly necessary to justify its removal. It may be noted, nevertheless, that all of these families, except the Mathildiidae, apparently have normal, rather high-spired dextral nuclei, whereas that of *Aclisina* is plano-spirally coiled and either concordant on top of the spire or, as shown clearly by Longstaff (3, 4) for many if not the majority of known species, tilted discordantly from the spire. Being guided by the parallel case of the *Promathildia—Mathildia* succession, this is here interpreted as the initiation of heterostrophy. Thus if *Aclisina* left Mesozoic descendants, and it is not necessary to assume that it did, one would expect to find in them an advance in the heterostrophy of the nucleus but certainly not a return to the simple, high-spired dextral nucleus such as *Turritella*, for example, seems to have. However, this argument does not exclude *Aclisina* from the Loxonematidae, which date from the early Paleozoic, for the genus might be considered as derived from one of its members through the

introduction of the beginnings of heterostrophy. Yet the very appearance of such an important new character should be sufficient to set *Aclisina* apart from the Loxonematidae.

Taxonomy itself seems to pass through an evolution which exhibits certain stages. In some groups these stages are passed through quickly and in others more slowly. In a large group, such as the gastropods, the earliest stage is the recognition of general relationships. In the next, the major group is subdivided along its broader, more obvious lines. In the third stage the refinements of classification begin to appear, and, naturally enough, are based largely on the study of recent material. The fourth stage involves the study of fossil material (although fossils may have been of some influence earlier) and every effort is made to fit the fossil forms, willy-nilly, into the existing scheme. We have been passing through this stage in studies of the Gastropoda. A breaking down and reformation seems to be required before development can proceed farther.

The classification, particularly as regards the older fossil forms, is in many parts highly artificial. Were it not for the fact that it is the product of undoubtedly earnest and capable workers, many parts of it would seem to be constructed more with an eye to convenience than to phylogenetic considerations. Many difficult problems are involved and the first step in solving them seems to lie in refusing to lump the smaller natural groups into established larger ones unless and until the reasons for so doing are compelling. Temporarily at least, smaller and less heterogeneous families are needed. In this way much may be accomplished in clarifying the relationships of groups that are lost in the large heterogeneous families which today lend misleading simplicity to our classification.

Since there is no reasonable certainty of their position in any of the established families, I propose for *Aclisina* and *Streptacis* the new family name Streptacididae. This family may be considered tentatively as derived from some murchisonid stock through loss of the band and the initiation of heterostrophy in the nucleus. The only other alternative is to consider it as derived from some nearly plano-spirally coiled forms, such as the euomphalids, and this seems as unacceptable as would be the derivation of forms with heterostrophic nuclei from sinistral ancestors.

The introduction of a new character into embryonic stages may seem anomalous. But it is well known that embryos as well as adults are capable of adaptation to special environments. Indeed such adaptation in certain deep-water species of gastropods with planktonic embryos

led Dall to forswear, temporarily at least, his well known allegiance to the law of recapitulation (17).

DESCRIPTION OF SPECIES

FAMILY STREPTACIDIDAE KNIGHT, N. FAM.

GENUS ACLISINA DE KONINCK, EMEND. DONALD

Dinaclina

ACLISINA STEVANSANA (MEEK AND WORTHEN)

Plate 1, figures 1 a-g; Text figures 1, a, h.

Turritella ?? *stevensana* MEEK AND WORTHEN, *1866*, Illinois Geol. Survey, Vol. 2, p. 382, pl. 27, figs. 8-8a.
Upper Coal Measures: North Branch Saline Creek, Gallatin County, Illinois.
Aclisina stevensana (MEEK AND WORTHEN), MARK, *1912*, Ohio Geol. Survey, 4th ser., Bull. 17, p. 313, pl. 16, fig. 5.
Conemaugh formation, Ohio. Several horizons and localities.
Aclisina formosa MARK, *1912*, Ohio Geol. Survey, 4th ser., Bull. 17, p. 314, pl. 15, fig. 7.
Conemaugh formation, Ohio.

	A	*B*	*C*
Number of whorls	12[a]	10	10
Height	7.07 mm.[a]	4.7 mm.	4.7 mm.
Width	2.07 mm.	1.52 mm.	1.52 mm.
Pleural angle	14½°	18°	18½°
Number of superior lirae	?	2	2
Number of lateral lirae	6	5	5
Number of inferior lirae	?	10±	10±
Ratio of height to width	3.4[a]	3.08	3.08
Ratio of height of body whorl to total	.35[a]	.40	.40

A. The cyrioplesiotype. (Plate 1, fig. 1a.)
B. A plesiotype, not quite mature. (Plate 1, fig. 1b.)
C. A plesiotype, not quite mature. (Not figured.)

[a]Estimated on the assumption that four apical whorls are missing.

High-spired, subcylindrical; sides straight or very slightly convex; whorl profile well rounded, slightly flattened above; sutures deep; aperture suboval; base rounded; shell thin. The plano-spiral nucleus lies flat upon the succeeding whorl. The earlier whorls are filled from the walls inward, the filling seemingly beginning at upper and outer sides. A columellar section is shown in text figure 1 h.

Superior revolving lirae faint or lacking; lateral lirae only moderately strong, widely spaced, the upper two or three frequently faint or lacking altogether; inferior lirae finer, rather crowded. A single lira is rarely represented by two. When this occurs the two divisions are rather widely spaced. Lirae somewhat cuesta-like with the steep face toward the spire.

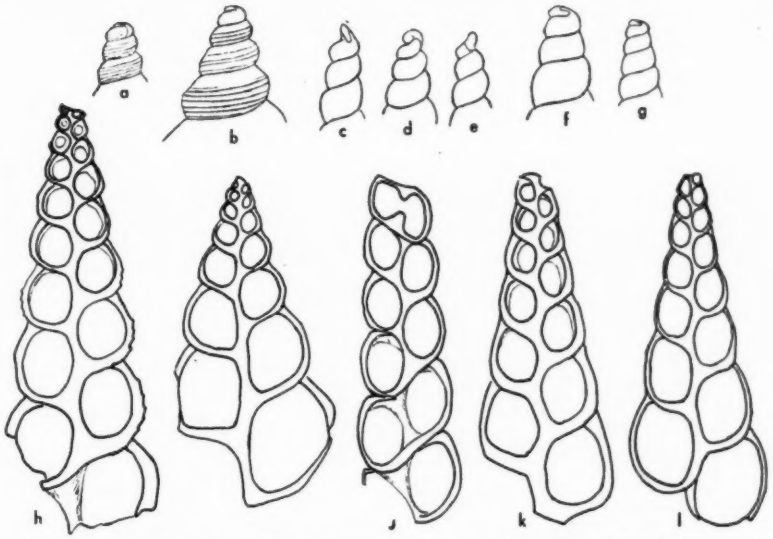


FIG. 1 a-g.—Apices of *Aclisina* and *Streptacis*. a, *A. stevensana* (M. & W.). b, *A. robusta* (Stevens). c, d, e, three aspects of *S. whitfieldi* Meek. f, *S. scalpta* Knight. g, *S. meeki* Knight. Based on camera lucida drawings. h-l.—Columellar sections of *Aclisina* and *Streptacis*. h, *A. stevensana* (M. & W.). i, *A. robusta* (Stevens). j, *S. whitfieldi* Meek, specimen slightly raised at upper end. k, *S. scalpta* Knight. l, *S. crenimarginis* Knight.

I am convinced that the variations in the number of lirae is not even of subspecific importance as there seems to be complete intergradation from a complete complement of lateral lirae (five) to only the three lower ones with no other correlatable difference in the specimens. The significant feature is apparently the potential number of lirae as indicated by specimens on which they find full expression.

A. stevensana differs from *A. swallowana* (Geinitz) in its more numerous and less prominent lirae, and from *A. robusta* (Stevens) in its less numerous lirae, rarely occurring in pairs, and more slender form. It is my opinion that *A. formosa* Mark is simply one extreme of variation within *A. stevensana*.

Top of Labette shale, Zone R, Locality 43, 524 specimens. Six juvenile specimens from Zone G at the same locality are also referred here. Cyrioplesiotype, Yale Peabody Museum, No. 13008.

ACLISINA ROBUSTA (STEVENS)

Plate 1, figures 2 a-f; Text figures 1 b, i

Aclis robusta STEVENS, *1858*, Am. Jour. Sci. (2), Vol. 25, p. 259, Coal Measures, Danville, Illinois; MEEK AND WORTHEN, *1873*, Illinois Geological Survey, Vol. 5, p. 596, pl. 29, fig. 6, Coal Measures, Danville, Illinois.

Aclis ? stevensoni WHITE, *1881*, U. S. Geog. Survey W. 100 Merid., Vol. 3, Supp. Appendix, p. xxxv, pl. 3, figs. 9a-b. Carboniferous, Coyote Creek, New Mexico.

Aclisina robusta (STEVENS), MARK, *1912*, Ohio Geol. Survey, 4th ser., Bull. 17, p. 313, pl. 16, fig. 4, various horizons and localities in the Conemaugh formation, Ohio.

Aclisina pumila MARK, *1912*, Ohio Geol. Survey, 4th ser., Bull. 17, p. 314, pl. 16, fig. 10, Portersville limestone, Portersville, Ohio.

	A	*B*	*C*	*D*
Number of whorls	12[a]	8[b]	9	10
Height	8.2 mm.[a]	4.7 mm.[b]	5.65 mm.	4.72 mm.
Width	3.4 mm.	2.6 mm.	2.7 mm.	2.0 mm.
Pleural angle	34°	46°	33°	20°
Number of superior lirae	?	10+	8	6
Number of lateral lirae	8+	10+	10	10
Number of inferior lirae	14+	15+	12	7+
Ratio of height to width	2.4[a]	1.8[b]	2.1	2.35
Ratio of height of body whorl to total	.5[a]	.56[b]	.54	.47

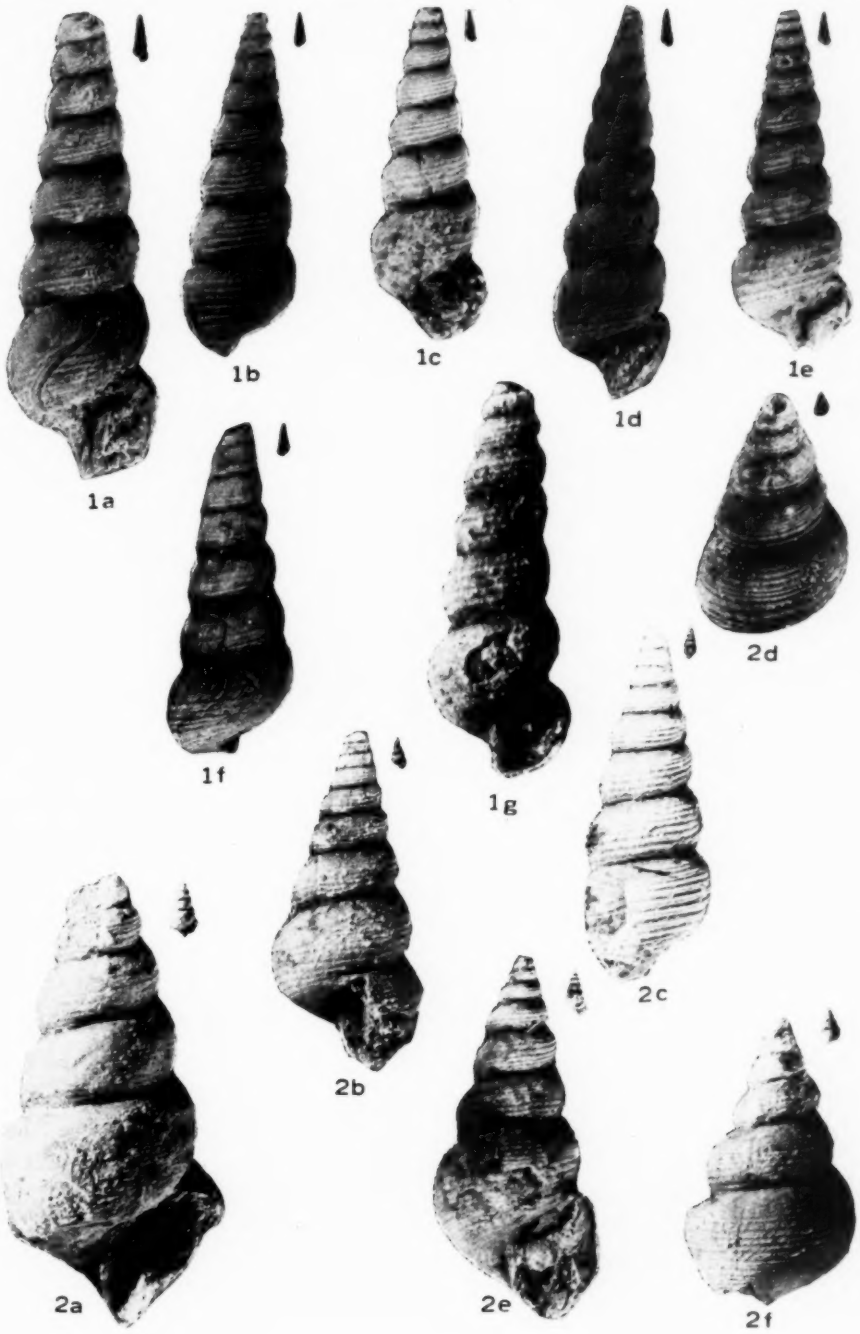
A. The cyrioplesiotype, probably fully mature. (Plate 1, fig. 2a.)
B. A plesiotype. (Plate 1, fig. 2e.)
C. A plesiotype. (Plate 1, fig. 2f.)
D. A plesiotype. (Plate 1, fig. 2c.)

[a]Estimated on the assumption that four apical whorls are missing.
[b]Estimated on the assumption that a single apical whorl is missing.

EXPLANATION OF PLATE 1

FIGS. 1—*Aclisina stevensana* (Meek and Worthen). All but 1g from Zone R, Locality 43. *a*, The cyrioplesiotype, probably a fully mature individual, × 10. Note the sinuate outer lip as delineated by growth lines. *b*, A plesiotype, × 10. Not fully mature. This specimen illustrates the full development of the revolving lirae. *c*, A plesiotype, × 10. Not fully mature. *d*, A plesiotype, × 10. Not fully mature. Note the weakening of the upper lateral lirae. *e*, A plesiotype, × 10. Not fully mature. Note the weakening of the superior, rather widely spaced lirae. *f*, A plesiotype, × 10. Not fully mature. Note almost complete loss of the two upper lateral lirae. *g*, An immature specimen from Zone G (× 20), referred to this species. Note nucleus.

2—*Aclisina robusta* (Stevens). All specimens from Zone R, Locality 43. *a*, The cyrioplesiotype, × 8. A large, apparently mature specimen. The subangular shoulders and flattening of the later whorls are due to mashing. *b*, A plesiotype, × 10. A moderately robust individual showing the lirae on the base. *c*, A plesiotype, × 10. A quite slender individual which shows well on the last whorl the doubled superior and lateral lirae. *d*, An immature individual, × 10. Oriented so as to show the superior costae. The apex is broken. *e*, A plesiotype, × 8. A moderately robust individual. *f*, A plesiotype, × 8. An individual of the more robust sort. The doubled lateral lirae can be seen.


1a
1b
1c
1d
1e
1f
1g
2a
2b
2c
2d
2e
2f

High-spired, conical, rather robust for the group; sides nearly straight or either slightly concave or convex; whorl profile well rounded, only slightly, if at all, flattened above; sutures deep; base rounded; aperture suboval; nucleus plano-spirally coiled for one whorl, lying flat on the succeeding whorl. Shell thin; the younger whorls apparently not filled in by secondary deposits. A columellar section is shown in text figure 1 i.

The ornamentation, particularly at later growth stages, consists of relatively numerous revolving lirae which characteristically occur in pairs. Superior lirae are exceedingly faint on the first four or five whorls, and when they become strong enough to be counted on the later whorls, are generally in pairs. The lateral lirae, which are larger and more conspicuous than those of the other two groups, number about five on the earlier and about ten on the mature whorls, where they are typically paired. The increase seems to come at different stages in different individuals, arising through the splitting off of a very fine branch from the upper side of each of the primary lirae. The branch lies close to the primary lira from which it originated and it very gradually increases in size until both are sub-equal. The inferior lirae are faint on the earlier whorls and, like the superior lirae, are already in pairs when they become distinct enough to be counted. The interspaces of all the lirae are narrow, though broader between the pairs than between the two members of the pair.

The relatively numerous paired lirae of all three groups is the outstanding character of the species and serves to distinguish it. The pleural angle, and consequently the ratio of height to width, varies to a remarkable degree as will be seen from the measurements above and from the specimens figured. The extremes would certainly be considered as separate species were it not for the fact that there is complete intergradation from one to the other. For this reason I do not hesitate to regard *A. pumila* Mark as simply an immature specimen of *A. robusta* with rather large pleural angle.

I have 177 specimens from the top of the Labette shale, Zone R, at Locality 43. A single immature specimen from Zone G at the same locality is somewhat doubtfully referred here. Cyrioplesiotype, Yale Peabody Museum, No. 13009.

STREPTACIS WHITFIELDI MEEK

Plate 2, figure 1; Text figures 1 c-e, j

Streptacis whitfieldi MEEK, *1871*, Acad. Nat. Sci. Phila., Proc., p. 173, Coal Measures, Danville, Illinois; MEEK AND WORTHEN, *1873*, Illinois Geol. Survey, Vol. 5, p. 596, pl. 29, fig. 1.

Number of whorls	11
Height	5.65 mm.
Greatest width	1.26 mm.
Pleural angle	9½°
Ratio of height to width	4.5
Ratio of height of body whorl to total	.36

Extremely high-spired, slender, subcylindrical; sides straight; whorl profile evenly rounded, not adpressed; sutures deep and notably oblique; whorls relatively high; aperture suboval; base rounded. The topmost whorl is plano-spirally coiled and stands at an angle to those following. The second whorl is typically free from the spire. The shell is thin and the younger whorls are apparently not filled by secondary deposits. A columellar section is shown in text figure 1 j.

Growth lines exceedingly faint and there are no other surface markings.

This species is characterized by its small size, deep, oblique sutures, entire lack of ornamentation, and upturned nucleus.

Top of the Labette shale, Zone R, Locality 43; 38 specimens. Cyrioplesiotype, Yale Peabody Museum, No. 13010.

STREPTACIS SCALPTA KNIGHT N. SP.

Plate 2, figures 4 a-b; Text figures 1 f, k

Number of whorls	12[a]
Height	11.8 mm.[a]
Greatest width	3.6 mm.
Pleural angle	19°
Ratio of height to width	3.2[a]
Ratio of height of body whorl to total	.40[a]

[a]Estimated on the assumption that four apical whorls are missing from the holotype.

High-spired, subconical; sides straight; whorl profile gently and evenly arched, very slightly adpressed; sutures moderately deep, not notably oblique; base flatly rounded; aperture suboval. The first whorl is plano-spirally coiled and lies flat upon the next succeeding. The shell is thin on the sides of the whorls and somewhat thicker on the base. The younger whorls do not seem to have a filling of secondary deposits. A columellar section is shown in text figure 1 k.

Smooth and unornamented except for rather obscure scratch-like striae which, on the later whorls, are only to be seen just above the lower line of suture. These mark former apertural edges but are neither costae nor growth lines in the ordinary sense.

S. scalpta hardly needs comparison with other species of the genus except perhaps *S. cerithiformis* (Meek and Worthen) and *S. crenimarginis* Knight. Both of these have crenulated upper edges to their whorls as well as other differences. The name is from the Latin *scalpta* (= scratched, engraved).

Top of the Labette shale, Zone G, at Locality 43. Sixty specimens at all stages of development. Holotype, Yale Peabody Museum, No. 13,011.

STREPTACIS CRENIMARGINIS KNIGHT N. SP.

Plate 2, figures 3 a-c; Text figure 1 l

Number of whorls	12[a]
Height	12 mm.
Width	4.04 mm.
Pleural angle	24°
Ratio of height to width	3.05
Ratio of height of body whorl to total	.47[b]

[a]Estimated on the assumption that eight apical whorls are missing from the holotype. A smaller specimen with nearly complete spire was used as comparison.
[b]Measured on a paratype.

High-spired, subconical; sides slightly concave; whorl profile very gently arched, somewhat pendant; adpressed; sutures shallow; base flatly rounded, aperture suboval. Nucleus not known. The shell seems rather thick for the genus and the opening of the earlier whorls appears to be constricted by secondary deposits which begin on the outer and upper sides. A columellar section is shown in text figure 1 l.

The first six or seven post-nuclear whorls are crossed by fine, close, transverse costae, which are most pronounced on the adpressed band at the upper suture. On later whorls the costae become obsolete except on the adpressed band, where they form distinct crenulations. It is not known whether the costae of the younger stages pass onto the base. Their lower ends disappear beneath the succeeding whorl on all my specimens. The course of the costae, which reflects that of the outer lip, is first downward for about one-third of the suture-to-suture distance with only a slight reversed obliquity, and then obliquely forward with a sweeping curve until it is lost from sight beneath the succeeding whorl.

The crenulations of the upper margins of the mature whorls of this species serve to distinguish it from any described form from the American Pennsylvanian except *S. cerithiformis* (Meek and Worthen) which has the same character, and perhaps *Chemnitzia attenuata* Stevens, an inadequately described form that has never been figured. *S. cerithiformis*, however, has a rounded whorl profile, rather deep sutures, and Meek and Worthen do not indicate the presence of transverse costae on the earlier whorls of their species. I can only attribute the *Cerithium*-like notch at the end of the columella of Meek and Worthen's only specimen of their species to the broken condition of the aperture which they are careful to remark.

I have seven specimens from Zone G at the top of the Labette shale at Locality 43. Holotype, Yale Peabody Museum, No. 13012.

STREPTACIS MEEKI KNIGHT N. SP.
Plate 2, figures 2 a-b; Text figure 1 g

Number of whorls	12
Height	4.4 mm.
Greatest width	1.4 mm.
Pleural angle	10°
Ratio of height to width	4.25
Ratio of height of body whorl to total	.32

High-spired, subcylindrical; sides straight; whorl profile gently rounded, slightly pendant, very slightly adpressed; sutures rather shallow; base rounded; aperture suboval. The nucleus is plano-spirally coiled and lies flat upon the succeeding whorl. I have not sectioned any of the four specimens, so cannot comment on the thickness of the shell nor the possible presence of secondary filling in the earlier whorls.

EXPLANATION OF PLATE 2

FIGS. 1—*Streptacis whitfieldi* Meek. The cyrioplesiotype, × 10. Specimen from Zone R, Locality 43.

2—*Streptacis meeki* Knight n. sp. *a*, The holotype, × 17. Specimen from Zone R, Locality 43. *b*, A paratype, × 24. Specimen from Zone G, Locality 43.

3—*Streptacis crenimarginis* Knight n. sp. *a*, A paratype, × 8. Note the transverse costae on the earlier whorls giving way to crenulations of the upper whorl margin alone on the later whorls. *b*, A paratype, × 10. *c*, The holotype, × 6. The holotype is the only fully mature specimen.

4—*Streptacis scalpta* Knight n. sp. Specimen from Zone G, Locality 43. *a*, The holotype, × 8. Side view to show form of sinus in outer lip. The aperture on this specimen is perfect but it was necessary to retouch the photograph to the extent of darkening the matrix in the sinus. *b*, The holotype, × 8. Apertural view.

UNIV. OF MICH.

Shell entirely smooth except for very scarce and exceedingly faint lines of growth.

This species compares in general expression with *S. scalpta* but is much smaller, has a much smaller pleural angle and lacks the characteristic ornamentation of that species. It does not have the deep, oblique sutures of *S. whitfieldi*, from which it also differs in the form of its protoconch.

Top of the Labette shale, Locality 43. Three specimens, including the holotype, from Zone R, one specimen from Zone G. Holotype, Yale Peabody Museum, No. 13,013.

TYPE SPECIMENS

All of the figured specimens of this and the preceding paper (1) are deposited in the Peabody Museum of Natural History, Yale University. Unfigured paratypes or pleisiotypes of many of the species are also deposited in the United States National Museum, Washington, D. C., in the paleontological collections of Washington University, St. Louis, Mo., and in the Musée Royal d'Histoire Naturelle de Belgique, Brussels.

REFERENCES

1. Knight, J. B.—The gastropods of the St. Louis, Missouri, Pennsylvanian outlier: The Pseudozygopleurinae. Jour. Pal., vol. 4, Supplement 1, 1930.
2. De Koninck, L. G.—Faune du calcaire Carbonifère de Belgique, pt. 3, Gastéropodes. Ann. du Mus. Roy. d' Hist. Nat. de Belgique, sér. paléont., vol. 6, 1881.
3. Donald, J.—Observations on the genus *Aclisina* de Koninck, etc. Quart. Jour. Geol. Soc. London, vol. 54, p. 45 et seq., 1898.
4. Longstaff, J. (née Donald)—Supplementary notes on *Aclisina* de Koninck, etc. Quart. Jour. Geol. Soc. London, vol. 73, p. 59 et seq., 1917.
5. Stevens, R. P.—Description of new Carboniferous fossils, etc. Am. Jour. Sci., (2), vol. 25, p. 258 et seq., 1858.
6. Shumard, B. F., and Swallow, G. C.—Descriptions of new fossils, etc. Trans. St. Louis Acad. Sci., vol. 1, p. 198 et seq., 1858.
7. Meek, F. B., and Worthen, A. H.—Illinois Geol. Survey, vol. 2, 1866.
8. Geinitz, H. B.—Carbonformation und Dyas in Nebraska, 1866.
9. White, C. A.—U. S. Geog. Surv. W. 100th Merid., vol. 3, Supp. Appendix, 1881.
10. Mark, C. G.—In Condit, Conemaugh formation in Ohio, Chap. 5, The fossils of the Conemaugh formation in Ohio. Ohio Geol. Survey, (4), Bull. 17, 19 2.
11. Meek, F. B., and Worthen, A. H.—Illinois Geol. Surv., vol. 5, 1873.
12. Meek, F. B.—Descriptions of new species of fossils, etc. Phila. Acad. Nat. Sci., Proc., vol. 23, 1871.
13. Miller, S. A.—North American Geology and Paleontology, 1889.
14. Weller, Stuart—A bibliographic index of North American Carboniferous invertebrates. U. S. Geol. Surv., Bull. 153.
15. Keyes, C. R.—On the fauna of the lower Coal Measures of central Iowa. Phila. Acad. Nat. Sci., Proc., 1888, p. 222 et seq.
16. Koken, E.—Ueber die Entwickelung der Gastropoden, etc. Neues Jahrb. f. Min., Geol., u. Pal. VI. Beil-Bd., p. 305 et seq.
17. Dall, W. H.—On the value of nuclear characters in the classification of marine gastropods. Jour. Wash. (D. C.) Acad. Sci, vol. 14, p. 177 et seq.

NEW PERMO-PENNSYLVANIAN FUSULINIDAE FROM NORTHERN OKLAHOMA

JOHN W. SKINNER
Indian Territory Illuminating Oil Company, Bartlesville, Oklahoma.

ABSTRACT

The following paper points out some of the difficulties encountered in the identification of the fusulinids of the Wabaunsee group in north central Oklahoma, and includes a description of five new species.

INTRODUCTION

For some time the writer has observed a large number of undescribed fusulinids in the upper part of the Pennsylvanian of north central Oklahoma. These forms, while bearing a superficial resemblance to species already described, are sufficiently different to make identification with these species very doubtful. The chief fusulinids of the Wabaunsee group in Nebraska and northern Kansas are *Triticites ventricosus*, *T. obesus*, and *T. acutus;* nearly all specimens may be referred with little difficulty to one of these species. However, as one comes south, identification is not so simple. *T. acutus* divides into or is replaced by several distinct types with intergrading forms, all of which are slender.

Further, the stock of large, ventricose forms is almost infinite in diversity. It is possible that most, if not all, of these are closely related to *T. ventricosus*, being modifications due to environmental conditions. Nevertheless, differences from the type are so great that the vast majority of individuals cannot be referred properly to that species; they should be distinguished as varieties or separate species. Typical specimens of *T. ventricosus* are exceedingly rare in this region.

In order to study the character of these fusulinids, large collections have been made from each horizon at several localities, and many individuals have been sectioned and studied. Only those forms which are most distinct and outstanding are dealt with in this paper—the others will require further careful study before decision can be reached regarding specific relationships. The morphological nomenclature and the classification used in this paper are those proposed by Dunbar and Condra.[1]

[1]Dunbar, C. O., and Condra, G. E., Fusulinidae of the Pennsylvanian System in Nebraska, Neb. Geol. Survey, (2), Bull. 2, 1927.

Recently Dunbar has studied some topotype material from Fischer de Waldheim's locality near Mjatschkowa and has found that *F. cylindrica* Fischer displays a "fusulinellid" rather than alveolar wall-structure. This fact was noted some years ago by J. S. Lee, but Lee apparently did not grasp the full significance of his find. Dunbar, in collaboration with Henbest, has discussed the consequences arising from this discovery, pointing out that since *Fusulina cylindrica*, like the forms which have subsequently been called *Fusulinella*, have a non-alveolar wall, the name *Fusulina* can no longer be used for those fusulinids with an alveolar wall which occur in the Permian and which have long been called *Fusulina*. The latter are left without a name. Dr. Dunbar and the writer are preparing a monograph on the Permian Fusulinidae of West Texas in which a new generic name will be proposed to embrace these forms. The present paper describes two species that fall in this class, but as the new generic name is not yet published, these are referred to "*Fusulina*," in the old sense of the term.

The writer is much indebted to Mr. Robert Roth who has offered many helpful suggestions, and to Dr. C. O. Dunbar who has offered valuable criticism.

DESCRIPTION OF SPECIES

GENUS "FUSULINA" AUCTORES (NON FUSULINA FISCHER)

"FUSULINA" FORAKERENSIS SKINNER N. SP.

Plate 4, figures 1-4

Test long and slender, sub-cylindrical with bluntly rounded ends. Length 10 to 14 mm., width 2.5 to 3 mm. Specimens of this size have from 6½ to 7 whorls. The form ratio is 1:4.33 to 1:4.8. Inner volutions are more fusiform and are bluntly to acutely pointed.

Septa strongly and regularly fluted from pole to pole, with coarse septal pores appearing in the sixth whorl. Septal count for the figured specimen is 14-17-19-23-27-26-27. Chomata moderately developed in the first four volutions, but absent in the outer ones. Tunnel angle very large, being usually 70 to 82 degrees; however, a few specimens have been observed in which the angle is as low as 60 degrees. Initial chamber small, diameter 115 to 135 μ. Texture of keriotheca coarse, 10 alveoli occupying about 195 μ.

This form is sufficiently similar to "*F.*" *longissimoidea* Beede to make identification from external form decidedly uncertain. However, upon sectioning the difference is at once apparent. The remarkable width of the tunnel alone is sufficient to distinguish the two species. Also, the initial chamber is notably smaller than in "*F.*" *longissimoidea*. In general the septa of "*F.*" *forakerensis* are fewer and the mature shells are 1 to 4 mm. longer and somewhat wider than Beede's species.

Horizon and locality. "*F.*" *forakerensis* occurs in the upper part of the Foraker limestone and is especially abundant in a shale break about 10 feet below the top of the formation. This shale has been correlated by Dr. G. E. Condra with the Stine shale of Nebraska, or basal Elmdale. Specimens have been collected from 5½ miles west of Cedarvale, Kansas, and from the SW. of Sec. 25, T. 26 N., R. 5 E., and the SW. of Sec. 35, T. 26 N., R. 6 E., in Oklahoma. Holotype, U. S. National Museum, No. 83,775.

"FUSULINA" TURKI SKINNER, N. SP.
Plate 3, figures 7-9

Test long, sub-cylindrical, slightly curved in such manner that one side appears distinctly convex in outline while the other is straight or slightly concave; ends bluntly rounded. Mature forms are 10 to 10.2 mm. in length, and 2.8 to 3 mm. in width. Shells of this size have from 6½ to 7½ volutions. Form ratio varies from 1:3.33 to 1:3.64. The three or four innermost volutions are inclined to be more slender in proportion and are rather acutely pointed.

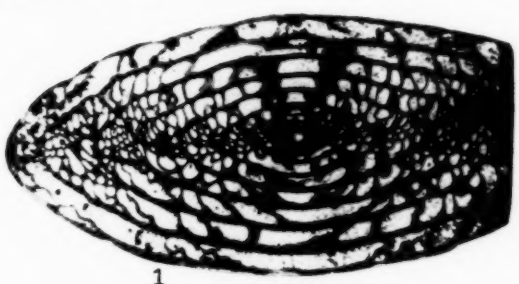
Septa are strongly and regularly fluted throughout. Septal pores are coarse and abundant, first appearing in the fifth whorl. The septa are fairly numerous, count for an average specimen being 13-20-21-22-28-33-35. Feeble chomata are present in the first three volutions, but are lacking from there outward. Tunnel angle large, ranging from 50

EXPLANATION OF PLATE 3

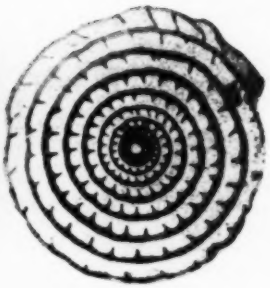
FIGS. 1-3.—*Triticites rothi* Skinner, n. sp. 1, Axial section, ×9. 2, Entire specimen of typical form, ×9. 3, Sagittal section, ×9.

4-6.—*Triticites koschmanni* Skinner, n. sp. 4, Sagittal section, ×9. 5, Entire specimen, ×7. 6, Axial section showing the strongly fluted septa and erratic course of the tunnel, ×9.

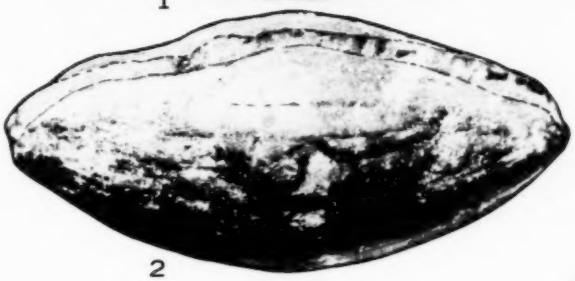
7-9.—*Fusulina turki* Skinner, n. sp. 7, Entire specimen showing the strongly fluted antetheca, ×7. 8, Sagittal section, ×9. 9, Axial section showing the rapid inflation of the outer whorls, ×9.



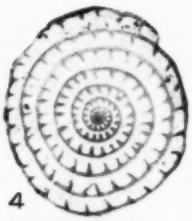
1



3

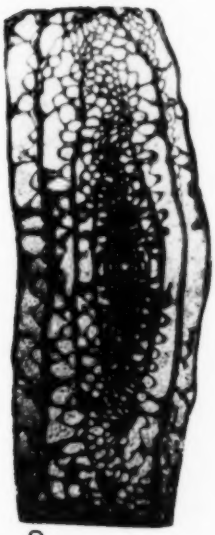


2

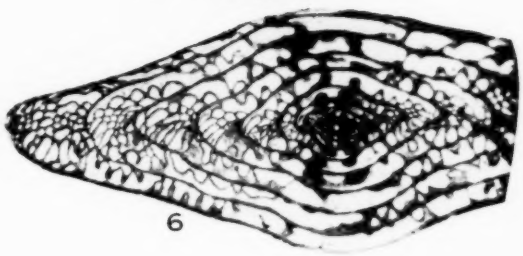


4

5

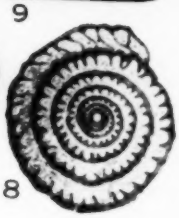


9



6

7



8

to 60 degrees. Proloculum rather small, 104 to 156 μ in diameter. Texture of the keriotheca coarse, 10 alveoli occupying 200 to 210 μ.

"*F.*" *turki* is found associated with "*F.*" *forakerensis*, to which it is most closely related. It is distinguished from the latter by (1) markedly shorter length, though the diameter is about the same, giving a considerable difference in the form ratio; (2) the distinctly narrower tunnel; (3) less well developed chomata; (4) the more intensely and evenly folded septa; and (5) somewhat earlier appearance of septal pores. Another feature worthy of note is the tendency of "*F.*" *turki* toward the *Schwagerina* type of coiling; that is, the first three or four volutions are tightly coiled, and then the shell suddenly expands so that the outer volutions are usually more than twice as high as the inner ones (Pl. 3, fig. 9). This feature distinguishes "*F.*" *turki* from both "*F.*" *longissimoidea* and "*F.*" *forakerensis*, neither of which displays this character. This species is named for Lon B. Turk, of Tulsa, Oklahoma.

Horizon and locality. "*F.*" *turki* occurs in the upper part of the Foraker limestone associated with "*F.*" *forakerensis* and is quite abundant. The localities are the same as those given for "*F.*" *forakerensis*. Also a few specimens which are tentatively referred to this species have been found in the Florena shale of Kansas. Holotype, U. S. National Museum, No. 83,776.

GENUS TRITICITES GIRTY

TRITICITES ROTHI SKINNER, N. SP.

Plate 3, figures 1-3

Test large, oval in outline, rather bluntly pointed at the ends. Mature forms range in length from 9 to 11 mm., and in width from 4 to 4.5 mm. The form ratio varies from 1:2 to 1:2.8, though in the majority of specimens it is about 1:2. Shells of mature growth have from 9 to 10 volutions and maintain the same ratio and shape down to the first whorl, the latter being nearly spherical.

Septa rather strongly fluted, not only in the axial zone, but, frequently, across the center of the shell as well. However, the fluting is neither so strong nor so regular as in species of "*Fusulina*." Septal pores appear in the seventh whorl and are abundant and very coarse. Septa are thinner than in *T. ventricosus*, and are usually less numerous. Septal count for three typical specimens is as follows:

Whorl	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
A.....	?	20	23	22	22	29	28	30	
B.....	11	18	17	21	22	24	26	25	25
C.....	12	17	20	22	24	32	29	30	35

Chomata are only moderately developed and disappear in the last volution. In some cases they appear to be rather strong, but tangential sections show that this is due to a marked thickening of the septa on either side of the tunnel. The tunnel angle is fairly large, ranging from 40 to 48 degrees, and, as a rule, the tunnel itself widens in an extremely regular fashion so that the sides are quite straight. The diameter of the proloculum varies from 122 to 200 μ, being in most specimens about 150 μ. Texture of the keriotheca is fairly coarse, 10 alveoli occupying 180 μ.

This form is closely related to *T. ventricosus*, but there are differences that make separation easy. Chief of these is the tunnel angle, which is usually about 46 degrees and rarely under 43 degrees, as compared to a maximum of 34 degrees in *T. ventricosus*. Also, *T. rothi* displays stronger septal fluting, and the coarse septal pores do not appear until about three volutions later than in *T. ventricosus*. The chomata are not nearly so well developed, the texture of the keriotheca is finer, and the proloculum is markedly smaller. The walls are somewhat thinner and the outer volutions are decidedly lower. This species is named for Robert Roth of Bartlesville, Oklahoma.

Horizon and locality. *T. rothi* marks a rather definite horizon at the top of the Foraker, that is, the previously mentioned Stine shale, where it is extremely abundant and is associated with "*Fusulina*" *emaciata*, "*F.*" *longissimoidea*, "*F.*" *turki*, and "*F.*" *forakerensis*. The specimens figured are from the SW. of Sec. 25, T. 26 N., R. 5 E., Oklahoma. A few specimens of *T. ventricosus* occur here, but they are scarce. Several specimens of *T. rothi* have been found in the Neva limsetone at Burbank, Oklahoma, but they are extremely rare. Holotype, U. S. National Museum, No. 83,778.

TRITICITES KOSCHMANNI SKINNER, N. SP.

Plate 3, figures 4-6

Test large, central portion distended, polar extremities usually abruptly extended, though in some specimens the lateral slopes fall away

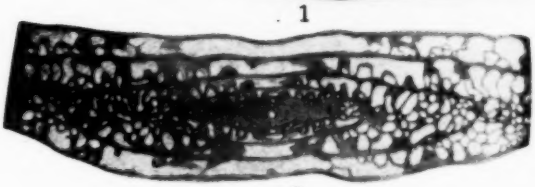
---

EXPLANATION OF PLATE 4

FIGS. 1-4.—*Fusulina forakerensis* Skinner, n. sp. 1, Entire specimen with a well preserved antetheca, × 7. 2, Axial section, × 9. 3, Same as fig. 2, before thin-sectioning, showing the unusually wide tunnel, × 7. 4, Sagittal esction, × 9.

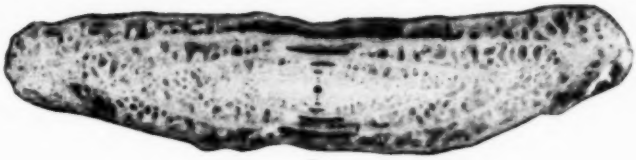
5-7.—*Triticites tumidus* Skinner, n. sp. 5, Entire specimen of typical shape, × 7. 6, Axial section showing the strong fluting of the septa, × 9. 7, Sagittal section, × 9.

1



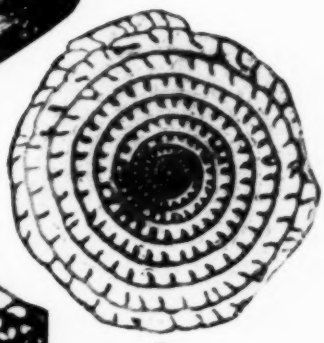
2

4

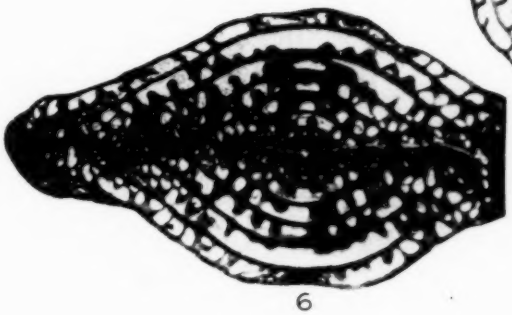


3

5



7



6

UNIV OF MICH

more evenly toward the ends. Fully grown specimens vary in length from 9 to 10.2 mm., and in width from 3.2 to 4 mm. Mature shells have 9 to 10 volutions. Shape of inner whorls, as seen in axial section, is rather irregular, but in general is that of an extended rhomb. Form ratio is 1:2.5 to 1:2.6.

Septa strongly but irregularly fluted from pole to pole. Septal pores appear in the eighth volution, but, while coarse, are not abundant. Septa are not numerous, the count for two typical specimens being as follows:

Whorls	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
A.....	8	13	13	15	19	23	25	26	Incomplete
B.....	10	16	15	19	21	26	27	31	Incomplete

Chomata are strongly developed but disappear in the last two volutions. The tunnel angle is fairly large, ranging from 40 to 48 degrees. The proloculum is minute, the diameter being 57 to 80 μ. Texture of the keriotheca is fine, 10 alveoli occupying about 120 μ.

This species is likely to be confused with *T. obesus*, and in external form the two are very similar. However, in axial section, they are decidedly unlike, for the tunnel angle of *T. koschmanni* is at least twice that of *T. obesus*, the proloculum is only about half as large, and shape of the inner whorls is quite different. In sagittal section, also, the difference is quite marked, the septal count for any volution being only a little more than half of a corresponding count for *T. obesus*. This last character, in conjunction with very thin walls, gives to a sagittal section a much more open appearance than is displayed by a similar section of *T. obesus*. The septal count is quite constant in all our sections of this species. This species is named for A. H. Koschmann.

Horizon and locality. This form is fairly abundant in the Neva limestone in the NE. of Sec. 28, T. 26 N., R. 6 E., and in the SE. of Sec. 26, T. 26 N., R. 5 E., Oklahoma. Holotype, U. S. National Museum, No. 83,777.

TRITICITES TUMIDUS SKINNER, N. SP.

Plate 4, figures 5-7

Test large, central portion sub-spherical, polar extremities often abruptly extended and bluntly to acutely pointed. In some cases the shell is nearly globular and rounds off smoothly to the ends. Mature specimens vary from 8.7 to 10 mm. in length, and from 4 to 5 mm. in width. Shells of this size have 9½ to 10½ volutions. The form ratio

ranges from 1:1.75 to 1:2.25. The inner whorls are globular to subrhombic in shape, and it is only in the outer two or three that any marked extension of the poles is observed.

Septa strongly but irregularly fluted, the vesicular zone frequently extending across the middle of the shell. Septal pores have not been observed. Septa are not very numerous, the count for a typical specimen being 10-10-19-20-23-27-28-34-36-38-incomplete. Chomata are strongly developed but become obsolete in the two outermost volutions. The tunnel angle is very small, ranging from 14 to 22 degrees, being usually about 18 degrees. The proloculum is rather small, its diameter ranging from 80 to 155 μ. The texture of the keriotheca is fine, 10 alveoli occupying about 130 μ.

This form is so different from any species previously described in this country that comparison is hardly necessary. The writer knows of only one form, *Schwagerina kansasensis* Beede, with which confusion is at all likely, and the similarity is only in outer appearance. However, *S. kansasensis* tapers more evenly toward the poles, the ends are more bluntly rounded, and the external furrows are less strongly impressed. A tangential section cutting no more than three whorls serves to distinguish these two forms. The strong chomata of *T. tumidus* are at once apparent. The fact that the two species occur together makes identification from examination of external characters above rather uncertain. However, *T. tumidus* is far more abundant than *S. kansasensis;* a single collection from the Neva limestone in the NE. of Sec. 28 T., 26 N., R. 6 E., contained 26 fusulinids of this general appearance, three of which proved to be *S. kansasensis*, while the others were *T. tumidus*. *T. plummeri* is somewhat similar in shape, but is only about half as large.

Horizon and locality. This large species is found fairly abundantly in the Neva limestone in the NE. of Sec. 28, T. 26 N., R. 6 E., and in the SE. of Sec. 26, T. 26 N., R. 5 E., Oklahoma. A few specimens were also found in the middle Foraker limestone, in the SW. of Sec. 35, T. 36 N., R. 6 E. Holotype, U. S. National Museum, No. 83,779.

NEW SPECIES OF CHESTER FOSSILS

A. H. SUTTON AND O. E. WAGNER, JR.
University of Illinois, Urbana, Illinois

ABSTRACT

Description of new species of brachiopods (*Productus*, *Camarotoechia*, *Pugnoides*, and *Spirifer*) and a crinoid (*Zeacrinus*) from the Chester beds, Upper Mississippian, of western Kentucky and southern Illinois are given.

INTRODUCTION

The present paper contains descriptions of new species of fossils, chiefly brachiopods, from the Chester series of Illinois and Kentucky. The writers wish to acknowledge the courtesy of Walker Museum, University of Chicago, for the loan of type specimens of the three species of *Productus* here described as well as of a number of type species of *Zeacrinus* for comparison with one of our new species.

DESCRIPTIONS OF SPECIES

CLASS BRACHIOPODA DUMERIL

ORDER PROTREMATA BEECHER

FAMILY PRODUCTIDAE GRAY

GENUS PRODUCTUS SOWERBY

PRODUCTUS SEMICIRCULARIS SUTTON AND WAGNER, N. SP.

Plate 5, figures 20-22

Description. Shell medium to large, slightly longer than wide, conspicuously acute toward the beak, hinge-line shorter than the greatest width which is near the anterior margin. The dimensions of two average specimens, cotypes, are: length from hinge-line to anterior margin 22 and 23 mm., length from umbonal region of pedicle valve to anterior margin 44 and 47 mm., greatest width 39 and 41 mm., length of hinge-line 26.5 and 28 mm., depth of visceral cavity between the two valves 17 and 18 mm.

Pedicle valve convex, almost a semicircle from beak to the anterior margin along each side of the mesial sinus, curving abruptly from the

umbonal region to the beak and more gently from the umbonal region to the anterior margin along the mid-line of the shell. The umbonal region protrudes conspicuously beyond the hinge-line. The surface of the valve curves abruptly to the cardinal margins with the curvature modified toward the cardinal extremities because of the prominent cardinal auriculations. The curvature is more gentle to the lateral and antero-lateral margins. Mesial sinus a broad, shallow depression which originates slightly anterior to the umbonal region and continues to the anterior margin, being most prominent about midway of the shell. The beak is small, pointed, and incurved slightly beyond the hinge-line. Surface of the valve marked by simple, rounded, moderately coarse, more or less continuous, radiating costae which are about equal in width to the intervening intercostal furrows. The costae average approximately one millimeter apart from crest to crest over most of the surface. The posterior portion of the valve is crossed by more or less conspicuous, concentric wrinkles which are strongest toward the cardinal extremities. Short spines and spine-bases are abundantly preserved on some specimens where they are arranged in rows on the costae, usually more numerous in the anterior portion of the shell. Groups of closely crowded spines, arranged in rows, occur on the greater portion of the surfaces of the cardinal auriculations. Internal characters not observed.

Brachial valve gently concave posteriorly, becoming more abruptly curved toward the anterior and lateral margins where it approaches closely the pedicle valve and is produced parallel to it. Anteriorly the mesial part of the valve is raised in a slight median fold to correspond to the sinus in the pedicle valve. Surface of the valve marked by costae and closely spaced concentric markings which, as a result of crossing of the two sets, gives an appearance of tubercles arranged in rows.

Remarks. The best distinguishing features of this species are the pointed shape of the pedicle valve which gives the greatest width in the anterior portion, the protruding umbonal region of the pedicle valve, and the almost semicircular outline of the pedicle valve. Spines are more abundantly developed on this than on any other Chester species of *Productus* which have come under observation.

Horizon and locality. Kinkaid limestone in Caldwell and Christian counties, Kentucky. Walker Museum No. 30916.

PRODUCTUS ABRUPTUS SUTTON AND WAGNER, N. SP.
Plate 5, figures 15-17

Description. Shell small to medium in size, longer than wide, hinge-line shorter than the greatest width which is near the anterior

margin. Dimensions of two average cotypes are: length from hinge-line to anterior margin 25 and 27 mm., length from umbonal region of pedicle valve to anterior margin 47 and 49 mm., greatest width 31.5 and 33 mm., length of hinge-line 23.5 and 24 mm.

Pedicle valve very convex from the umbonal region to the anterior margin and sharply curved from the protuberant umbo to the beak which is only slightly incurved beyond the hinge-line. The surface curves abruptly to the cardinal margins and is only slightly modified at the cardinal extremities. Cardinal auriculations almost obsolete. The curvature is abrupt to the lateral margins, the sides of the valve being nearly at right angles to the plane of the upper surface midway of the length. The curvature is less abrupt in the anterior portion. Most of the specimens show no trace of a mesial sinus but on some a broad, shallow depression originates in the umbonal region and becomes indistinct before the anterior margin is reached, but in a few it reaches the margin. The beak is small, pointed, and incurved to or slightly beyond the hinge-line. Surface of the valve marked by rounded, moderately coarse, radiating costae which increase in number by bifurcation throughout the length of the shell but more frequently in the posterior and anterior portions. Locally the costae are interrupted for short distances so as to appear as series of elongate nodes. In some specimens the costae alternate in size in the anterior part of the shell. A few, more or less obscure wrinkles, which are most prominent toward the cardinal extremities, occur in the posterior part of the valve. Spine-bases are few and inconspicuous and apparently obsolete on some specimens. When present they are usually confined to a few on each side of the beak arranged in oblique rows from the hinge-line to points on the lateral margin in front of the cardinal extremities.

Brachial valve only imperfectly known. It is only slightly concave in the posterior region but curves more abruptly in the anterior and lateral areas and is produced parallel to the pedicle valve. Visceral cavity between the valves rather deep. Surface marked by radiating costae similar to those of the pedicle valve and by conspicuous concentric wrinkles. No mesial fold.

Remarks. This species is especially characterized by the abrupt slopes of the pedicle valve to the lateral margins, the absence or obsolescense of the mesial sinus, and by the character of the costae mentioned above. It resembles somewhat *P. inflatus* McChesney of the lower formations of the Chester but may be distinguished by the absence of a pronounced mesial sinus and by its more pointed beak.

Horizon and locality. Paint Creek limestone near Claxton, Caldwell County, Kentucky. Walker Museum No. 30645.

PRODUCTUS INCURVATUS SUTTON AND WAGNER, N. SP.
Plate 5, figures 18-19

Description. Shell large, longer than wide, the hinge-line shorter than the greatest width which is toward the anterior margin. The dimensions of three specimens of average size are: length from hinge-line to anterior margin 27, 33, and 28 mm., length from umbonal region of the pedicle valve to anterior margin 36, 42, and 33 mm., convexity of pedicle valve 19, 19, and 18 mm., length of hinge-line 30, 28, and 32 mm.

The pedicle valve is gibbous, with a prominent umbonal region which is protuberant beyond the hinge-line. The surface curves abruptly from the umbonal region toward the margins and the cardinal extremities are flattened to form small auriculations. From the umbonal region to the beak the surface is incurved toward the hinge-line. The surface curves more gently toward the anterior margin. The mesial sinus is obsolete or exists as a broad, shallow depression which originates in the umbonal region. The beak is small, pointed, and incurved. Surface of the valve is marked by rather strong, rounded, radiating costae which increase by bifurcation usually on the middle portion of the shell, becoming conspicuously alternate in size toward the anterior portion of the shell. The posterior portion of the shell is also marked by more or less conspicuous, wrinkle-like, concentric markings which are stronger toward the cardinal extremities. Spine-bases are scarce, occurring along the costae, and especially on the cardinal auriculations. Internal characters not observed.

EXPLANATION OF PLATE 5

FIGS. 1-3.—*Camarotoechia claxtonensis* Sutton and Wagner, n. sp. Pedicle, brachial, and lateral views of the holotype.

4-7.—*Spirifer parvus* Sutton and Wagner, n. sp. Brachial, pedicle, anterior, and lateral views.

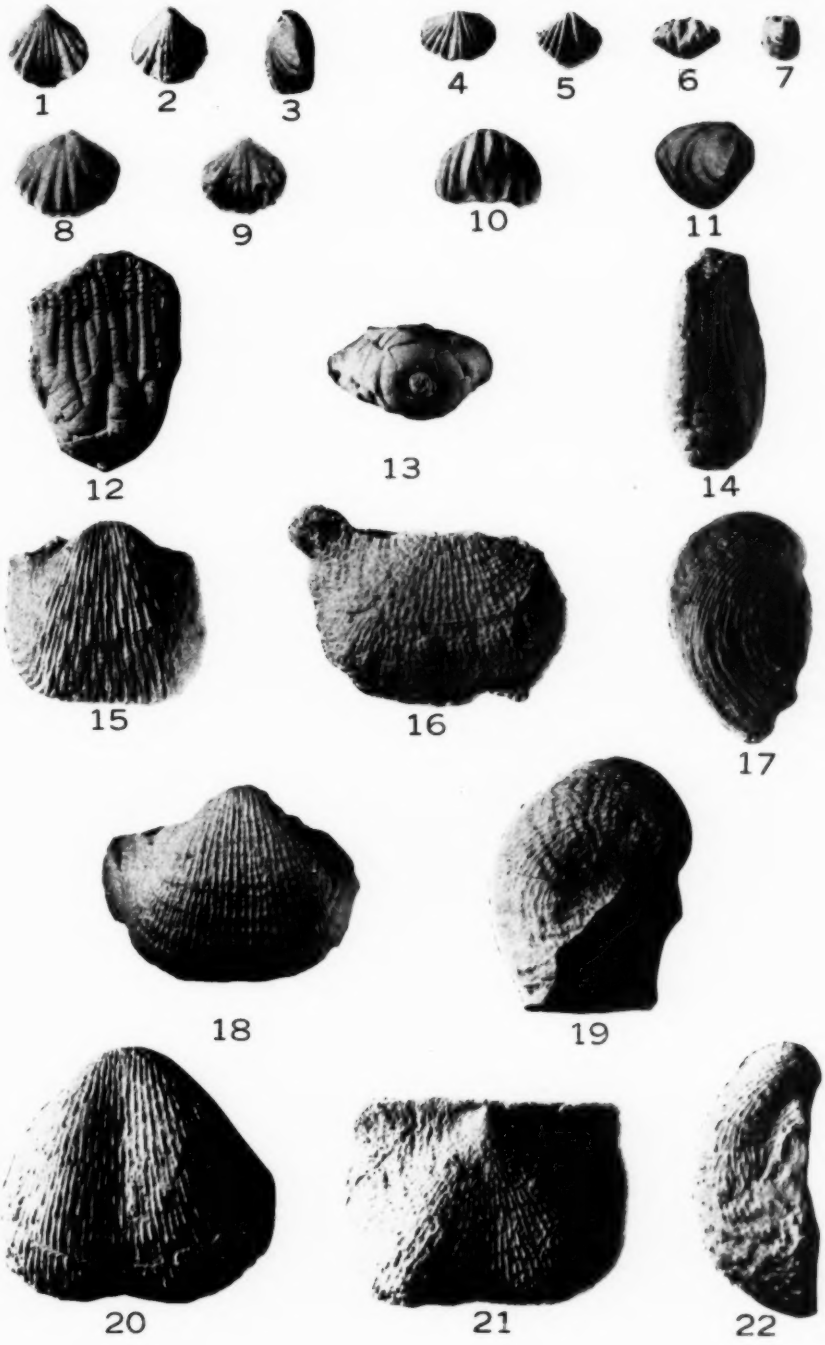
8-11.—*Pugnoides subovatus* Sutton and Wagner, n. sp. Brachial, pedicle, anterior and lateral views.

12-14.—*Zeacrinus chesterensis* Sutton and Wagner, n. sp. 12, View of the left side of the holotype. 13-14, Views of the base and anal interray of the holotype.

15-17.—*Productus abruptus* Sutton and Wagner, n. sp. Pedicle, lateral, and brachial views. Brachial valve incomplete. W. M. No. 30645.

18-19.—*Productus incurvatus* Sutton and Wagner, n. sp. Pedicle and lateral views of a nearly complete specimen. W. M. No. 34452.

20-22.—*Productus semicircularis* Sutton and Wagner, n. sp. Pedicle, brachial, and lateral views of nearly complete specimens. W. M. No. 30916.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

Brachial valve not known.

Remarks. The distinguishing features of this species are the gibbous, highly arched pedicle valve with its protuberant umbo, the obsolete mesial sinus, and the coarse costae which alternate comspicuously in size in the anterior portion of the shell.

Horizon and locality. Clore limestone in southeastern Illinois and western Kentucky. Walker Museum No. 34452.

Family RHYNCHONELLIDAE Gray

Genus CAMAROTOECHIA Hall and Clarke

CAMAROTOECHIA CLAXTONENSIS Sutton and Wagner, n. sp.

Plate 5, figures 1-3

Description. Shell small, subovate in outline, longer than wide with the greatest width slightly anterior to the middle, postero-lateral margins nearly straight or very gently concave, meeting at the beak in an angle of about 80 degrees, the antero-lateral and anterior margins rounded. Dimensions of the holotype are: length of pedicle valve 11 mm., length of brachial valve 9.5 mm., greatest width 10 mm., thickness 6 mm., width of sinus in front 6 mm.

Pedicle valve moderately convex, the greatest convexity posterior to the middle, longitudinal convexity produced anteriorly with only a slight decrease of curvature in the sinus, but the valve is almost flat anteriorly on each side of the sinus. Posteriorly the surface is regularly convex transversely in the central portion of the valve but curves more abruptly toward the opposite valve as it approaches the lateral margins and it is continued in a nearly vertical direction to the edge. The mesial sinus originates posteriorly to the middle of the valve, is broad and almost flat across the depressed portion and produced anteriorly into a rounded lingual extension. The lateral slopes of the sinus rise at an angle of about 45 degrees to the top of the bounding plications. The beak is small, sharply pointed, and curved over the umbo of the opposite valve but not touching it. Delthyrium triangular and nearly filled by the beak of the brachial valve. Plications originate near the beak; they are simple and rounded, three occupying the sinus and five on each lateral slope, becoming successively smaller toward the cardinal extremities. Fine concentric markings occur over most of the surface conspicuously on the anterior portion. Shell structure fibrous which gives the apearance of fine striations where the shell is partly exfoliated. Internal characters not observed.

Brachial valve less convex than the pedicle along the mid-line of the shell with the curvature more pronounced in the posterior portion. The curvature is much more abrupt toward the lateral and antero-lateral margins. The mesial fold originates in the middle of the valve where it is low and becomes higher anteriorly. It is formed more by the abrupt curvature of the antero-lateral portions of the valve than it is by any distinct elevation. Beak is strongly incurved beneath that of the opposite valve, plications and other surface markings similar to those of the pedicle valve.

Remarks. This, so far as is known, is the only species of *Camarotoechia* ever described from the Chester series. It may be readily distinguished by the typical camaroteochoid shape, surface markings, and fibrous shell structure.

Horizon and locality. Paint Creek limestone near Claxton, Caldwell County, Kentucky.

Genus PUGNOIDES Weller

PUGNOIDES SUBOVATUS Sutton and Wagner, n. sp.

Plate 5, figures 8-11

Description. Shell small, broadly subovate in outline, wider than long, the greatest width near the middle, the posterior-lateral margins nearly straight and forming an angle of 105 to 115 degrees at the beak, the antero-lateral and anterior margins rounded. The dimensions of two specimens are: length of pedicle valve 12 and 11 mm., length of brachial valve 11 and 10 mm., greatest width 14 and 12.5 mm., thickness 10 and 8.5 mm., width of sinus in front 8.2 and 7 mm.

The pedicle valve is convex in the umbonal region and very slightly convex transversely across the middle part. The surface slopes very gently from the umbonal region to the antero-lateral margins and curves abruptly to the postero-lateral margins. From the beak to the anterior margin along the median line the surface describes nearly a semicircular curve. The mesial sinus originates about midway of the length of the valve, being nearly flat transversely in the bottom and produced anteriorly in a rounded lingual extension. The plications are simple, originating in the umbonal region, obsolete at the beak, low and rounded posteriorly, becoming stronger and more angular toward the front, two or three occupying the bottom of the sinus and none on the sides of the sinus. Upon each lateral slope there are four to six plications which become successively weaker toward the cardinal extremities. Fine,

regular, concentric lines of growth cover the surface of the valve, becoming stronger toward the outer margins. The beak extends above that of the brachial valve and is sharply pointed. Internally, there are two well defined dental lamellae.

The brachial valve is much more strongly convex than the pedicle, the greatest convexity being near the front, the surface sloping in a long, gently convex curve from the point of greatest elevation to the beak. Along the median line in the umbonal region there is a shallow median sinus. The lateral slopes from the umbonal region are convex and rather abrupt. From the umbonal region to the antero-lateral margins the surface describes nearly a semicircular curve. The mesial fold originates near the middle of the valve, being but slightly elevated at first and becomes strongly elevated anteriorly. The plications are entirely similar in form and number to those of the pedicle valve and alternate with them, and the concentric lines of growth are likewise similar. The beak is strongly incurved beneath that of the pedicle valve. The shell structure of both valves is finely fibrous and impunctate. Internally the structures are typical of the genus *Pugnoides;* the brachial valve contains a median septum.

Remarks. This form resembles very much the one described from formations somewhat higher in the Chester as *Rhynchopora (?) perryensis* by Weller. In his description of that species, Weller makes the statement that if it were not for the punctate character of the shell it would be placed in the genus *Pugnoides* without hestiation. Careful examination has failed to reveal any punctae on our specimens and since the internal characters are typical of *Pugnoides*, we feel no hesitation in assigning our species to that genus. The fine fibrous structure of the shell may give the appearance of punctations when the shell is broken across the fibres.

Horizon and locality. Specimens have been obtained from the Paint Creek (Upper Gasper) limestone of Breckenridge County, Kentucky, and from a calcareous horizon in the Cypress sandstone in Christian County, Kentucky.

Family SPIRIFERIDAE King

Genus SPIRIFER Sowerby

SPIRIFER PARVUS Sutton and Wagner, n. sp.

Plate 5, figures 4-7

Description. Shell small, broader than long, hinge-line a little shorter than the greatest width, the cardinal extremities obtusely angular. The average dimensions of thirteen specimens are: length of

pedicle valve 7 mm., length of brachial valve 6 mm., greatest width 8.7 mm., thickness 4.9 mm., length of hinge-line 7.5 mm.

Pedicle valve moderately convex with the surface curving abruptly from the umbonal region to the cardinal margin, sloping more gently to the lateral and antero-lateral margins, and slightly compressed toward the cardinal extremities. Beak small, pointed, and incurved. Cardinal areas concave, more curved toward the beak and with the lower and more flattened portion directed at an angle of about 90 degrees to the plane of the valves. The lateral margins are sharply defined and slope from the beak to the cardinal extremities in a gently curved line. The surface is vertically striated. Each lateral slope of the pedicle valve is marked by six or seven simple, rounded plications, those bounding the mesial sinus being strongest and becoming successively weaker toward the cardinal extremities. A mesial sinus of moderate depth and sharply defined by strong bounding plications, originates at the beak where it is narrow. It increases in width toward the anterior margin and is marked by a single, simple, rounded plication which originates in the umbonal region.

Brachial valve less convex than the pedicle and with a narrower cardinal area. The greatest width is near the middle and the valve is compressed toward the cardinal extremities. The mesial fold is narrow, originates near the beak where it is scarcely elevated, and becomes more sharply elevated toward the anterior margin. It is marked by a shallow rounded median furrow which originates in the umbonal region. The beak is small and incurved. The surface is marked by plications similar to those of the pedicle valve.

In addition to the plications, the surfaces of both valves are marked by fine, radiating striae, fine, sublamellose comcentric markings, and stronger concentric lines of growth which are crowded toward the anterior margin.

Remarks. *Spirifer parvus* appears to have its nearest affinity with *S. leidyi* N. and P. of the Chester, from which form it differs in the much smaller size, fewer plications, single median plication in the mesial sinus, and different angle between the pedicle cardinal area and the plane of the valves. It differs from young forms of other Chester spirifers, *S. increbescens* Hall, *S. breckenridgensis* Weller, and *S. leidyi* N. and P. in that the latter three forms all possess in the mesial sinus a median plication and one plication on each lateral slope of the sinus, the outer plications originating from the lateral bounding plications, whereas *S. parvus*

possesses only a single median plication in the sinus. It may be distinguished from the Chester spiriferinas which possess a single median plication in the sinus by the punctate shell structure of the latter forms.

Horizon and locality. This little shell has been collected from all of the Chester limestones around the Western Kentucky Coal Basin.

Class CRINOIDEA Miller

Order INADUNATA Wachsmith and Springer

Family POTERIOCRINIDAE Roemer

Genus ZEACRINUS Hall

ZEACRINUS CHESTERENSIS Sutton and Wagner, n. sp

Plate 5, figures 12-14

Description. The type specimen of this species is about average size for the genus. The dorsal cup is low, round, and basin-shaped. The columnar cavity is rather deep and the surface of the calyx smooth. The column is small and round with a very small axial canal.

The infrabasals are within the columnar cavity, being hidden by the end of the column. There are five basal plates, four of which have an acute distal angle, the fifth being longer, narrower, and truncated above for the reception of the first anal plate. There are five pentagonal radials, each about twice as wide as long, the greatest width being along the upper edges which are truncated for the support of the five primary brachials, four of which are pentagonal, cuneiform, and axillary, the fifth situated in the anterior ray being quadrangular and about twice as wide as high. The anterior ray bears, besides the latter, two other primary brachial plates, the lower of which is narrowly quadrangular and the other pentagonal, cuneiform, and axillary. On the right antero-lateral ray the primary brachial bears on its right superior edge four secondary brachials and on its left superior edge five secondary brachials. The primary brachial of the left antero-lateral ray bears four secondary brachials on each side. The right postero-lateral ray bears three secondary brachials on the right and four on the left superior edge of the primary brachial. The left postero-lateral ray bears four secondary brachials on the right and six on the left superior edge of the primary brachial. Other irregular divisions occur above the secundibrachs.

The anal area contains five plates, a radianal and four anals. The radianal is long, narrow, and pentagonal and is entirely within the dorsal

cup, with its proximal angle extending into the basal cavity. It is truncated on its lower edges by two basals, on the right side by a radial, on the left by the first anal plate, and on its upper edge by the second anal plate. The first anal plate is small and hexagonal, truncated by a basal below, by the radianal and the second anal plate on the right, by the third anal plate above, and by a brachial and a radial on the left side. Its lower portion is within the dorsal cup. The second anal plate is slightly larger than the first, hexagonal, and lies above the radianal and

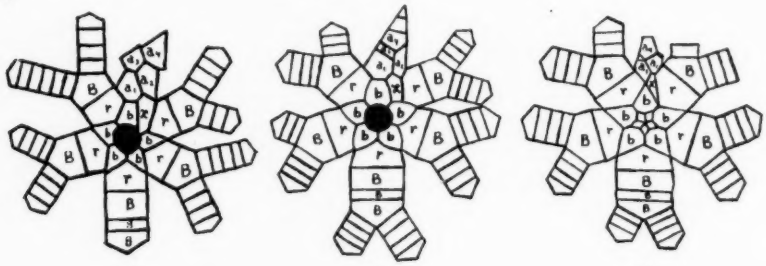


FIGURE 1.—A. Analysis of the plates of the calyx of *Zeacrinus chesterensis* Sutton and Wagner, n. sp. B. Analysis of the plates of the calyx of *Z. doverensis* Miller and Gurley. C. Analysis of the plates of the calyx of *Z. wortheni* Hall. Basals—b. Radials—r. Brachials—B. Radianal—x. Anals—a.

below the fourth anal plate, between the first and third anal plates on the left and a radial and brachial on the right. The third anal plate is the smallest. It is pentagonal, situated above the first anal plate, below the fourth, and to the left of the second anal plate. The fourth anal plate is the largest plate in the anal inter-ray. It is quadrangular, acute at the top, and is situated above the second and third anal plates between the rays. The arms are uniserial, twenty-seven being present at the top of the specimen.

Remarks. A number of forms which appear to be very closely related occur in the genus *Zeacrinus*. The essential differences between them are the number and shape of the anal plates, the position and shape of the radianal plate, and the number of secondary brachials or secundibrachs in the various arms. This group includes *Z. chesterensis* Sutton and Wagner, *Z. wortheni* Hall,[1] and *Z. doverensis* Miller and Gurley.[2]

[1]James Hall, Paleontology of Iowa, Report, Vol. 1, Pt. 2, p. 683, 1858.

[2]S. A. Miller and Wm. F. E. Gurley, Ill. St. Mus. Nat. Hist., Bull. 8, pp. 34-35, 1898.

All three of these species are alike and all differ from other described species of the genus in having two additional quadrangular brachial plates intercalated between the radial and the cuneiform brachial plate of the anterior ray. Several of the other described species have one additional quadrangular plate in the same position. The essential differences between these three species are shown in the diagrammatic representations of the plates in the calyx of each form (Fig. 1).

Z. chesterensis differs from *Z. wortheni* in a number of respects. The posterior basal plate of the former is truncated where it is attached to the first anal plate, the radianal is pentagonal whereas that of *Z. wortheni* is four-sided, and *Z. chesterensis* lacks the small triangular anal plate which is present in *Z. wortheni*, having instead a five-sided plate in the same position. The upper anal plate of *Z. chesterensis* is acute at the top while that of *Z. wortheni* is truncated. Finally the number of secondary brachials in the different rays is different in the two species.

The differences between *Z. chesterensis* and *Z. doverensis* are still more marked. Whereas the two species already discussed have five plates in the posterior (anal) inter-ray, *Z. doverensis* has seven. In this species, as in *Z. wortheni*, the radianal does not enter as far into the lower part of the dorsal cup as does that of *Z. chesterensis*, and in *Z. doverensis* the number of secondary brachials in the different rays differs from those of the other two species. The distinctive features of *Z. chesterensis* are: (1) a radianal which extends almost or quite to the infrabasals, (2) the four-sided, acute upper anal plate, and (3) the different number of secondary brachial plates in the different rays, six on the left side of the left postero-lateral ray, five on the posterior side of the right antero-lateral ray, three on the right branch of the right postero-lateral ray, and four on all of the others. In the anterior ray on which, because of crushing, it is impossible to be certain, there appear to be four on each branch.

Horizon and locality. The type of this species was collected by Mr. Beryl Bean from the Paint Creek formation in Hardin County, Illinois.

A MIOCENE *HALIOTIS* FROM SOUTHERN CALIFORNIA

W. P. WOODRING
California Institute of Technology, Pasadena, California

ABSTRACT

Haliotis is very rare in the fossil state, as are most rock-clinging mollusks. Specimens from the base of the Modelo formation of the Santa Monica Mountains represent the first Miocene abalone found in America. It closely resembles modern species living on the Pacific Coast.

Haliotis—the familiar abalone of rocky stretches of coast along the Pacific—has an extensive distribution in regions bordering the Pacific Ocean. The largest species are found on the Pacific coast of North America and in Japanese waters, but the greatest number are recorded from Australian seas.[1] Only one species (*H. dalli* Henderson, Galapagos) is known on the Pacific Coast of America south of Lower California. Also only one (*H. pourtalesii* Dall, Florida) has been found in the western Atlantic, and only one (*H. tuberculata* Linné) lives in European waters.

Fossil remains of *Haliotis* are rare. In Europe a doubtful species, "*Haleotis?*" *antiqua* Binkhorst,[2] is on record from the Upper Cretaceous (Maestrichtian). I do not have access to Binkhorst's report, but both Stoliczka and Cossmann doubt whether this Cretaceous species is a *Haliotis*. The first genuine European species are of Miocene age and are found in the Aquitanian of Aquitaine, the Burdigalian of the Vienna Basin, the Helvetian of the Piedmont Basin, and the Pontian of southern Russia. All the American fossil species are from the Pacific Coast. F. M. Anderson[3] described an Upper Cretaceous species, "*Haliotis*" *lomaensis*, discovered by H. W. Fairbanks at Point Loma, near San

[1]Pilsbry, H. A., Man. Conch., vol. 12, p. 73, 1890.

[2]Binkhorst van den Binkhorst, J. T., Monographie des gastéropodes et des céphalopodes de la craie supérieure du Limbourg, p. 81, pl. 5a2, fig. 4, Bruxelles et Maestricht, 1861. Since writing this account I have had opportunity to examine Binkhorst's book. His species is not at all convincing as a *Haliotis*. It is a mold, probably of a trochoid shell on which the spines near the aperture may have been broken. Dr. G. D. Hanna kindly called my attention to another doubtful Cretaceous species, "*Haliotis*" *cretacea* Lundgren (Kongl. Sven. Vet.-Akad. Handl., vol. 26, no. 6, p. 52, pl. 2, fig. 1, 1894).

[3]Anderson, F. M., Proc. Calif. Acad. Sci., 3rd ser., Geology, vol. 2, No. 1, p. 75, pl. 9, fig. 183, 1902.

Diego. Through the kindness of Dr. G. D. Hanna, Curator of Invertebrate Paleontology of the California Academy of Sciences, I was permitted to examine the type and only specimen of this species, which fortunately survived the hazards of the San Francisco fire of 1906. The specimen is very small (length 12.7 mm., width 9.2 mm.) and smooth, aside from a shallow groove that lies above the four narrow perforations and a faint ridge lying above the groove. The shell is broken away at the apex, but aside from a slight twist of about 90 degrees, no trace of a spire can be seen. The shell also is broken away along the edge adjoining the perforations, revealing a narrow shelf, as in *Haliotis*. In view of the antiquity of this specimen and in view of the absence of a well-defined spire, it is doubtful whether it is a genuine *Haliotis*, though it may represent an ancestral genus. The only American Miocene species is the one described. The Pliocene and Pleistocene records on the following page are available. Dr. U. S. Grant IV kindly permitted me to have access to his notes in compiling this list:

The specimens here described were collected at the base of the Modelo formation on the south slope of the Santa Monica Mountains along the east side of Brown Canyon, where an isolated patch of basal Modelo rocks, consisting of slate fragments, rests on an uneven surface of the slate and argellite forming the crest of the range. This locality was discovered by Dr. H. W. Hoots during work carried on for the United States Geological Survey. The fossils found here have an interesting ecologic facies, which I think accounts for the presence of the first American Miocene abalone. Seven of the eight determinable genera of mollusks collected here are rock-clingers or nest among stones. *Haliotis* and *Tegula* cling to rocks; *Navicula*, better known as *Arca* s. s., and *Lima* nest among stones; *Hinnites* cements itself to stones; and *Mytilus* is attached by its byssus to rocks or other objects. It is quite clear that these animals lived on and among the rocks at the foot of a slate cliff against which the advancing Modelo sea beat as it crept over the present site of the eastern Santa Monica Mountains. The "Pectens," representing the only other determinable genus, probably flapped around in the kelp. In view of the abrupt overlaps and striking differences in stratigraphic succession in adjoining regions, such rocky coasts must have been common along the shores of the Tertiary seas of California, but as I have pointed out elsewhere,[1] rock-clinging mollusks generally are rare as fossils. The probability that they will be ground to pieces in the surging surf or dissolved as they lie in the constantly moving water

[1]Woodring, W. P., Carnegie Inst. Washington Pub. 385, pp. 30-31, 1928.

PLIOCENE AND PLEISTOCENE SPECIES OF *HALIOTIS* FROM THE PACIFIC COAST

Species	*Formation and Locality*	*Age*	*Source*
Haliotis fulgens Philippi	Arnold's Upper San Pedro formation, Deadman Island	Late Pleistocene	Arnold, Mem. Calif. Acad. Sci., vol. 3, pp. 336-337, 1903
Haliotis fulgens Philippi	Spanish Bight, San Diego	Late Pleistocene	Ditto
Haliotis cracherodii Leach	Chiton bed, Point Fermin, San Pedro	Late Pleistocene	E. P. and E. M. Chace, Lorquinia, vol. 2, No. 6, p. 2, 1919
Haliotis rufescens Swainson	Chiton bed, Point Fermin, San Pedro	Late Pleistocene	Ditto
Haliotis sp.	Base of Fernando group, north of Arroyo Santa Rosa, Ventura County	In beds of early Pleistocene age	H. G. Schenck, oral communication
Haliotis rufescens Swainson	Lawson's Wildcat formation, Humboldt County	Pliocene	J. P. Smith, oral communication
Haliotis sp.	Fernando group, Los Angeles	In beds of late Pliocene age	Moody, Univ. Calif. Pub. Bull. Dept. Geol., vol. 10, No. 4, pp. 43, 46, 1916
Haliotis sp.	Pico formation, Santa Paula quadrangle	Pliocene	H. G. Schenck, oral communication
Haliotis rufescens Swainson	Between Timber Canyon and Santa Paula Creek, Ventura County	Pliocene	U. S. Grant IV and H. R. Gale, written communication
Haliotis corrugata Gray	O'Hare Canyon, Ventura County	Middle Pliocene	Ditto
Haliotis sp.	San Diego formation, San Diego	Middle Pliocene	Moody, op. cit.
Haliotis cf. *rufescens* Swainson	Cedros Island, Lower California	Middle Pliocene	Jordan and Hertlein, Proc. Calif. Acad. Sci., 4th ser., vol. 15, No. 14, p. 449, 1926
Haliotis fulgens Philippi	Elsmere Canyon, Los Angeles County	Lower Pliocene	U. S. Grant IV and H. R. Gale, written communication

before burial is too great for many of them to survive. Even if the remains are buried before being obliterated they may be exhumed during a storm of unusual severity and again run the gamut of buffeting by waves and rocks. In addition to these hazards conditioned by the mode of life, the shell of *Haliotis* decays in a particularly rapid and effective manner, at least in the air, as anyone knows who has dug them out of kitchen middens. They have a dead earthy or chalky appearance and readily flake. This disintegration seems to be due to the extraction of the original organic material that binds together the thin laminae. The fortunately preserved Miocene fossils from the Santa Monica Mountains represent some unusual condition or sequence of events. They may represent shells that dropped into relatively deep water at the foot of a cliff or narrow rock shelf after the animals died. At all events they point to rapid and successful burial close to the place where they lived and died.

GENUS HALIOTIS LINNÉ

Linné, 1758, Syst. Nat., ed. 10, p. 779.
Type (by subsequent designation, MONTFORT, *1810, Conch. Syst.*, vol. 2, p. 119). *Haliotis asininus* Linné (emendation for *asinina*), Recent, Indo-Pacific.

It is unfortunate that Montfort chose as the type of *Haliotis* the least "typical" of all the species known to Linné or to anyone since Linné's time, but he did it deliberately according to his own words (p. 120). I suppose that inasmuch as *Haliotis*—a classical transcription of the vernacular name—means sea-ear, he considered that the type species should be one having a name suggesting some kind of ear and the ass-ear *Haliotis* was the only one that filled the requirements. This species has a long narrow shell and long foot, unlike any other. By those who recognize subdivisions of the genus it is placed in the subgenus *Teinotis* H. and A. Adams,[1] of which it is the type,[2] making it a perfect synonym of *Haliotis* s. s. The species of *Haliotis* form so homogeneous a group that subdivisions for the most part are not recognized. If it is desirable to recognize them, *Padollus* Montfort[3] is the earliest name to consider for the common kind of *Haliotis*. This name might be rejected, however, as a *nomen dubium* on the grounds that the type species is unrecognizable.

[1]Adams, H. and A., Gen. Rec. Moll., vol. 1, p. 442, 1854.

[2]By subsequent designation, Stoliczka, Cret. fauna Southern India, vol. 2, p. 388, 1868.

[3]Montfort, Denys de, Conch. Syst., vol. 2, p. 115, 1810; type (by original designation), *Padollus rubicundus* Montfort (? = *Haliotis tricostalis* Lamarck; see Pilsbry, Man. Conch., vol. 12, p. 123, 1890), Recent, "Africa."

In that event Cossmann's[1] inadvertent designation of *Haliotis incisa* Reeve as the type of *Sulculus* H. and A. Adams[2] makes *Sulculus* available for the group of *Haliotis tuberculata* Linné, the familiar European species which has been accepted as the type of *Haliotis* since Lamarck cited it as the sole example in 1799.[3]

HALIOTIS PALAEA WOODRING, N. SP.
Plate 6, figures 1-3

A moderately large strongly sculptured *Haliotis* bearing an indeterminate number of open holes. The shell is angulated along the row of perforations, which lie close to the edge. Between the perforations and the edge lies a deep narrow groove. The edge of the shell adjoining the perforations is abruptly bent to form a narrow columellar shelf, which slopes inward. The sculpture consists of strong spiral cords and of irregular crude lumps or waves more or less arranged in axial series.

Length 59.5 mm.; width 40 mm. (holotype, immature).

Type material. Holotype, immature specimen (Calif. Inst. Tech. No. 1205), figured. Paratypes, fragment of large specimen and imperfect very young specimen (Calif. Inst. Tech. No. 1206), both figured.

Type (and only) locality. South slope of Santa Monica Mountains, south end of ridge along east side of Brown Canyon, 1250 feet N. 3° W. from 756-B. M. along Los Angeles City Boundary, Sawtelle Quadrangle; H. D. Hobson, H. W. Hoots, R. D. Reed, and W. P. Woodring collectors (Calif. Inst. Tech. Loc. No. 52); base of Modelo formation (early upper Miocene).

The three specimens consist of molds, to which is attached some shell material, replaced by calcite. The holotype is the most perfect specimen, but is immature. The fragment of a large shell has a length of 98 mm., indicating a shell of much larger size than the holotype.

[1]Cossmann, M., Essais Paléoconch. Comp., vol. 11, p. 315, 1918.

[2]Adams, H. and A., Gen. Rec. Moll., vol. 1, p. 443, 1854.

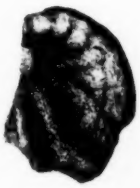
[3]Lamarck, J. P. B. M. de, Mem. Soc. Hist. Nat. Paris, p. 77, 1799.

EXPLANATION OF PLATE 6

FIGS. 1-3.—*Haliotis palaea* Woodring, n. sp. 1, Holotype, immature specimen, × 1. Calif. Inst. Tech. No. 1205. Base of Modelo formation, Santa Monica Mountains, Calif. Inst. Tech. Loc. No. 52. 2, Paratype, very young specimen, × 1. Calif. Inst. Tech. No. 1206. Same locality. 3, Paratype, fragment of large specimen, × 1. Calif. Inst. Tech. No. 1206. Same locality.

1

1a



2

3

UNIV. OF MICH.

This Miocene species clearly belongs to the group of *H. corrugata* Gray, as defined by Pilsbry,[1] which is characteristic of the Pacific Coast of North America, all the species now living there except one (the black abalone, *H. cracherodii* Leach) belonging to it. The fossil species is perhaps most similar to *corrugata* itself, especially in the position of perforations and in the strong spiral cords, but the groove below the perforations and the lumps near the apex are more pronounced. *H. kamtschatkana* Jonas has the deep groove and apical lumps, but the shell is more elevated and both groove and perforations are closer to the edge.

Dating of the basal deposit of the Modelo formation at the *Haliotis* locality is afforded by echinoids of the genus *Astrodapsis*, as described elsewhere.[2]

[1]Pilsbry, H. A., Man. Conch., vol. 12, pp. 76, 80, 1890.

[2]Woodring, W. P., Miocene echinoids of the genus *Astrodapsis* from Southern California (in preparation).

PALEONTOLOGICAL NOTES

LATE DEVONIAN FORAMINIFERA FROM IOWA[1]

A. O. THOMAS
University of Iowa, Iowa City, Iowa

A few years ago while screening some marly shale in quest of echinoid remains from the Lime Creek beds of Iowa, the writer came upon a few rotaloid tests of undoubted foraminifera. Later search added to the number. Investigation brought out the fact that although foraminifera are fairly common in most Paleozoic systems the Devonian is notably lacking in this type of remains. Only one occurrence of foraminifera from the Devonian of Europe, has been described hitherto.[2] The present material from the Iowa Devonian will, it is hoped, stimulate careful search in all promising Devonian strata. The material belongs to the genus *Endothyra* and is referred to one species.

ENDOTHYRA GALLOWAYI THOMAS, N. SP.
Plate 7, figures 1-9

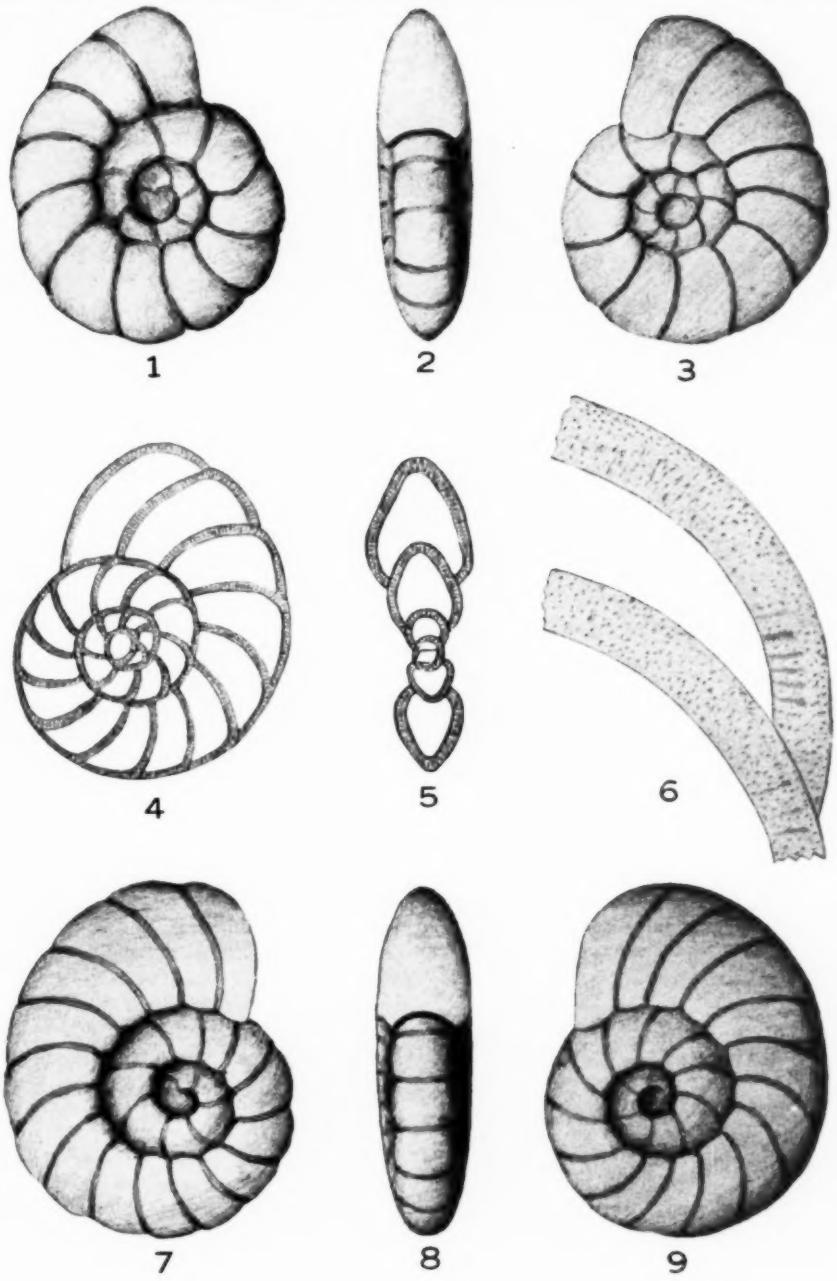
Test free, discoidal, rotaloid in appearance, almost bilaterally symmetrical; umbilici depressed and partly filled with hyaline, calcareous material, through which all the chambers of the spire may be seen; edge sharply rounded; periphery tending to be lobulate; whorls closely coiled and only slightly embracing those within; chambers short, closely appressed, twelve to fourteen in the last whorl; sutures curved, a little depressed, limbate, and of clear yellow material; wall calcareous, secreted by the animal, imperforate, yellowish in color, consisting of very minute crystals of calcite, practically transparent thus showing the white calcite filling the chambers; in some specimens the wall has a thin, dark outer layer, and a thicker inner layer, thus corresponding to the tectum and keriotheca of *Triticites;* surface smooth; aperture a narrow slit at the base

[1]This contribution was submitted shortly before Professor Thomas' death, Jan. 13, 1931, and appears posthumously. The editor has made minor changes and corrections.

[2]Terquem, Bull. Soc. Géol. France, ser. 3, vol. 8, 1880, p. 414.

EXPLANATION OF PLATE 7

FIGS. 1-9.—*Endothyra gallowayi* Thomas, n. sp. 1, 3, Opposite side views of holotype, No. 12-017. 2, Apertural view of the same specimen showing the compressed periphery of the last whorl and the narrow, slit-like aperture. 4, Median section of paratype, No. 12-008. 5, Section of paratype, No. 12-008. 6, Part of median section of paratype, No. 12-012, showing wall structure. 7, 9, Opposite side views of a form with more numerous chambers than the holotype; paratype, No. 12-011. 8, Apertural view of the same specimen.



UNIV. OF MICH.

of the last septal face and so situated as to be divided equally by the median plane. In most specimens the last chamber is so broken or distorted that the aperture is obscure. Diameter 0.5 to 0.6 mm.; thickness 0.15 to 0.2 mm.

Remarks. *Endothyra gallowayi* exhibits considerable variation in the number and size of the chambers. However, the limited amount of material at hand does not seem to warrant the erection of other species or varieties at the present time.

This Devonian species is near enough to the genotype, *E. bowmani* Phillips of the Carboniferous, to be included within the genus. It differs, however, in three respects: (1) the test is more nearly bilaterally symmetrical, but there are other species of *Endothyra* in the Carboniferous and Permian which are as nearly bilaterally symmetrical; (2) in the more closely appressed chambers which are shorter and relatively broader than in the other species of the genus; and (3) in the more sharply rounded back of the whorl. In the short chambers and sharply rounded back, *E. gallowayi* resembles *Orobias*, but in the latter the chambers are still shorter, the back of the whorl more sharply angled and its whorls embrace to the umbo. In these features, *Orobias* reveals characters which strongly suggest derivation from the stock of *Endothyra gallowayi*.

This species of Devonian *Endothyra* is of special significance in showing that the walls of Middle Paleozoic foraminifera are not agglutinated but are made up of calcium carbonate secreted by the animal. The structure of the wall is similar to that of most Upper Paleozoic larger foraminifera. In these the wall consists of an outer thin dark layer called the tectum, and an inner thicker layer, the osseum, which in some cases is alveolar and called the keriotheca, and in other cases nearly structureless and nearly transparent and called the diaphanotheca.

The material upon which this description is based has been examined carefully by Dr. J. J. Galloway, of Columbia University. In the preparation of the description he has rendered valuable aid and suggestions and the sections were prepared under his supervision. The writer takes pleasure in naming this interesting species in his honor. The illustrations were prepared and assembled by the late Mr. C. H. Belanski, of the University of Iowa.

Occurrence. Known only from the *Devonocidaris jacksoni* zonule near the middle of the Cerro Gordo member of the Hackberry. The specimens studied are from Birds Hill, four miles southwest of Rockford, Iowa.

Types. Holotype No. 12-017, paratypes No. 12-008, 12-010, 12-011, 12-012, 12-015, State University of Iowa.

A NOTE ON *LEPIDOCYCLINA HILLI* CUSHMAN

T. WAYLAND VAUGHAN
Scripps Institution of Oceanography, La Jolla, California

Cushman described from a single specimen collected by Mr. R. T. Hill in the Quallava sandstone of Costa Rica,[1] a species of *Lepidocyclina* to which

[1]Cushman, J. A., U. S. Geol. Survey, Prof. Paper 125, p. 60, pl. 15, fig. 1; pl. 16, fig. 2, 1920.

he applied the name *Lepidocyclina hilli*. In order to ascertain the features of the embryonic and equatorial chambers, Dr. Paul Bartsch, of the U. S. National Museum, gave me permission to grind the side of the specimen opposite to the side figured by Cushman.

The specimen is microspheric and, therefore, cannot be placed in any of the usually recognized subgenera of *Lepidocyclina*. The equatorial chambers are hexagonal. Near the center the transverse may be longer than the radial diameter; while near the periphery the radial is usually the longer diameter. Many chambers are obscurely spatulate.

Cushman's description and figures of the exterior of the test are good and the only significant information that I can add, to what he has already published, is that the type specimen is a microspheric individual. It is probable that the species belongs in the same group of species as *L. supera* (Conrad). Such a relationship is suggested by the equatorial chambers.

THE VELASCO-MENDEZ CONTACT IN THE VICINITY OF THE EBANO FIELD, MEXICO

HENRY J. MORGAN, JR.
Atlantic Oil Producing Company, San Angelo, Texas

The Velasco-Mendez contact, as studied by microscopic examination of washed samples from drilled wells, is marked by an abrupt change in microfaunas. The fauna of the Lower Velasco contains about 80-90 percent of pelagic foraminifera, the majority of which are one species of *Globigerina*. The underlying Mendez contains few globigerinas or pelagic foraminifera of any sort, the majority of species being bottom-living forms with rather heavy calcareous tests. The contrast in fauna alone would lead one to suspect, if not an unconformity, at least a period of post-Mendez pre-Velasco time of no deposition. Other evidence corroborates this.

The diamond drill-hole No. T-22, located about 2.5 km. south of Ebano Hill and near well Ebano No. 10, furnished cores for study of the actual Velasco-Mendez contact.

At 375 feet in this well is a one-inch band of fine-grained conglomerate in a bentonitic matrix. The hard components, that is, the parts not soluble in water, are white, nodular, well-rounded fragments resembling soft limestone; they effervesce freely in dilute hydrochloric acid. The matrix of the conglomerate was impure bentonitic material with occasional nodules of pure, greenish and very soft bentonite. Immediately above this conglomerate is a 10-foot section of reddish, compact, fine-grained sandy shale containing mica. This shale grades upward into normal blue-gray, bentonitic Velasco, so that at 11 feet above the conglomerate the shale is blue-gray and without mica. From 375 to 380 feet, the bottom of the hole, the core consists of a fine-grained, dark red, terra-cotta-like shale, having a somewhat oxidized appearance and

containing no mica. Microscopic examination of the washed residue of the samples disclosed the following characters.

MICROSCOPIC EXAMINATION

364 Feet. Sample consists almost entirely of calcareous foraminiferal tests, only a few arenaceous forms being present. Globigerinas about 80 per cent of the sample which has appearance of typical Velasco shale.

366 Feet. Mica, 7 per cent; quartz grains (sand), 30 per cent; calcareous foraminifera, 5 per cent; the remainder being coarsely arenaceous foraminiferal tests. The foraminifera with calcareous tests consist mainly of the following genera: *Anomalina*, *Lenticulina*, *Rotalia*, and *Bulimina*. The large, coarsely arenaceous and agglutinated forms are represented mostly by *Clavulina*, *Tritaxia*, and *Gaudryina*. The arenaceous forms have remarkably coarse tests, and megascopically have a dark reddish color. Under the microscope, however, the red color is not so pronounced and the tests are seen to be speckled by small fragments of some black mineral incorporated in the tests. The structure of the test is sometimes obscured by the coarseness of the wall material.

368 Feet. Mica, 0.1 per cent; sand, trace; sample composed mostly of calcareous foraminifera. About 5 per cent of large, fine to coarse arenaceous tests are present, the former predominating greatly over the latter. *Globigerina* about 75 per cent of the entire sample.

369 Feet. Mica, 0.5 per cent; sand, 5 per cent; finely arenaceous foraminifera, 30 per cent; coarsely arenaceous foraminifera, 10 per cent; the remainder calcareous foraminifera with a large percentage of *Globigerina*.

370 Feet. Mica, 1 per cent; sand, 2 per cent; calcareous foraminifera, 30 per cent; the remainder coarsely arenaceous foraminifera. A sample from 371 feet is almost identical in appearance and composition.

372 Feet. Mica, 1 per cent; sand, 30 per cent; calcareous foraminifera, 5 per cent; the remainder coarsely arenaceous foraminifera. About the same as the 371-foot sample except for the varying percentage of composition. The arenaceous forms exhibit the same color and structure as in the preceding sample but are, in general, smaller.

373 Feet. Mica, 2 per cent; sand, 5 per cent; calcareous tests, 1 per cent, remainder large, coarsely arenaceous foraminifera. Much like the preceding sample except for the almost total absence of *Globigerirna*.

375 Feet. One-inch bed of conglomerate. Examination of the washed residue led to the discovery of a number of tests of species of *Globotruncana*, *Pseudotextularia varians* and an *Eouvigerina* which are characteristic of the Mendez. No diagnostic Velasco foraminifera were found. Nearly all the foraminiferal tests are coated with the same limy, calcareous material of which the nodules in the conglomerate are composed. Several diagnostic Mendez foraminifera were found almost completely imbedded in the nodules. This fact indicates that the sample was not contaminated either in taking or in washing. In hydrochloric acid most of the conglomeratic material was digested after lively effervescence, but about 20 per cent remained as insoluble residue. A marked calcium test was obtained from the part of the material which was soluble in hydrochloric acid, while test for sulphate gave negative results. Fusion of the insoluble residue in sodium bicarbonate before the blowpipe and evaporation and solution of the bead in nitric acid gave gelatinous silica as the end product.

376 Feet. This sample shows typical uppermost Mendez foraminifera with practically no foreign material and exhibits the peculiar red-colored, oxidized tests which are generally characteristic of the uppermost Mendez shale. Sample from 380 feet, same.

In the Huasteca Petroleum Company well, Pedro No. 17, one sample just above the Mendez shale contains much sand, some oil-stained calcite, some calcareous Velasco foraminifera tests and a large number of the coarsely arenaceous forms described above. This zone was also found in wells Ferronales No. 45, Huasteca Petroleum Company wells Ebano No. 35, La Dicha Nos.

135, 151 and 152. It has been found in numerous wells drilled in Chapacao, Tullilo, Limon and Salinas Haciendas, in all cases just above the Mendez shale but these occurrences were not, unfortunately, recorded at the time of observation. The zone has not been found in all wells which penetrate the Velasco-Mendez contact, but that is to be expected when the fact that the sample interval—normally ten feet— might vary enough to miss this thin zone entirely.

In the course of auger-sampling work in the vicinity of Huesteca well, Raya No. 1, this zone was encountered many times. In one case, the zone was drilled from the first sample depth two feet to the underlying Mendez shale.

During the progress of surface geological work in Tancasneque Hacienda, north of the Ebano area across the Tamesi River, an outcrop sample from this lowermost basal Velasco was turned into the laboratory. Further investigation, by digging, disclosed the conglomerate described above to lie one foot below the point where the first sample was taken. A detailed description of the microscopic examination of these samples follows:

M-220—One foot above conglomerate. Mica, 1 per cent; sand, 35 per cent; coarsely arenaceous forms constitute nearly all of the remainder of this sample.

K-221. Conglomerate similar to the one described in Test Hole T-22.

K-222. One foot below the conglomerate. Uppermost Mendez shale with the tests showing the peculiar, characteristic, red terracotta color of that Mendez horizon. Most of the tests were badly oxidized and corroded.

K-223. Two feet below the conglomerate. Uppermost Mendez shale fauna with the tests showing the characteristic color and oxidation.

Another Velasco-Mendez contact was found in surface exposure in an arroyo 3.5 km. north of kilometer 621 on the Tampico-San Luis Potosi railroad. The conglomerate here has a thickness of 5 inches, is distinctly varicolored and fine-grained with many small calcareous nodules imbedded in a bentonitic matrix as in the other two localities described. The variation of colors is due to the different colors of the bentonite composing the matrix. Only two feet of the basal Velasco bed was exposed above the contact and only a few inches of Mendez below the contact. Microscopic examination of the washed residues of Velasco and Mendez showed typical basal Velasco and typical upper Mendez as in T-22 and at sample station K-221, described above. Diagnostic Mendez foraminifera were found in the conglomerate but no diagnostic Velasco foraminifera. Mendez foraminifera were found imbedded in and coated by the material composing the nodules. Lithologically, the contact is sharp and faunally the change is equally abrupt, for shale samples taken one inch above and below the contact show typical basal Velasco and uppermost Mendez species, respectively.

It is reported that the conglomeratic Velasco-Mendez contact has been found in cores in test holes drilled near the eastern boundary of Llano de Silva Hacienda and also that it has been observed at the outcrop in Cacalilao Hacienda.

The presence of this conglomerate at the contact between the Velasco and Mendez is proved to exist in an area some 40 kilometers long and 25 kilometers wide, and it is most probable that this conglomeratic contact and lowermost basal Velasco zone will be found throughout the northern part, at

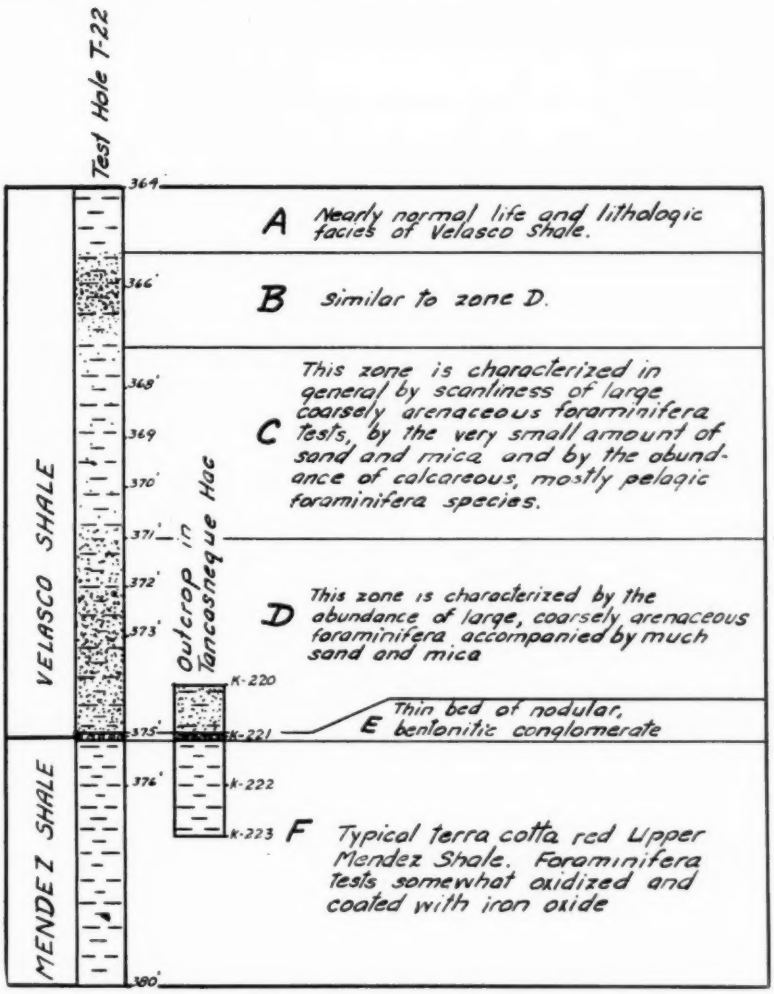

Test Hole T-22
364'
366'
368'
369
370'
371'
372'
373'
375'
374'
380'
VELASCO SHALE
MENDEZ SHALE
Outcrop in Tancasneque Hac
K-220
K-221
K-222
K-223
A Nearly normal life and lithologic facies of Velasco Shale.
B similar to zone D.
C This zone is characterized in general by scantiness of large coarsely arenaceous foraminifera tests, by the very small amount of sand and mica and by the abundance of calcareous, mostly pelagic foraminifera species.
D This zone is characterized by the abundance of large, coarsely arenaceous foraminifera accompanied by much sand and mica
E Thin bed of nodular, bentonitic conglomerate
F Typical terra cotta red Upper Mendez Shale. Foraminifera tests somewhat oxidized and coated with iron oxide

Figure 1. Sections at Velasco-Mendez contacts.

least, of the Tampico Embayment area. It is possible, however, that the shallow water conditions at the beginning of the Velasco may not have existed over the entire area of Mendez deposition. In that case, the change from a Mendez to a Velasco fauna might be modified somewhat, due to deeper water conditions.

The aspect of the Mendez fauna, excepting the lower 150 to 600 feet, suggests a moderately deep sea with remarkably uniform depositional conditions. This is attested by the comparatively uniform fauna for hundreds of

feet. Many common species occur throughout the entire thickness of the formation with hardly enough change to give them varietal rank. The uniform depositional conditions suggested by the faunal aspect is further borne out by the lithologic appearance of the lower 700-850 feet, for it is remarkably thick-bedded, compact and homogeneous throughout. It is only in the upper 150-300 feet that a suggestion of a shallower sea is seen. This is evidenced by influx of a number of new foraminiferal species, and also by a somewhat larger fauna. The lithology of this upper Mendez horizon bears out the faunal evidence because it is predominantly red in color with the tests becoming more oxidized and more coated until just below the Velasco-Mendez contact they are decidedly oxidized, or even badly corroded.

It is generally agreed that bentonite is the result of alteration of a glassy, igneous rock, usually a tuff. Since bentonite is known in the Mendez from a tuff which is in the initial stages of alteration to a pure bentonite and since the most striking characteristic of the conglomerate is its bentonitic matrix, it is reasonable to conclude that it was originally a tuff. The persistence of this very thin bed over the area is rather difficult to explain as the result of sedimentary processes. Explanation of the calcareous nodules which are characteristic of the conglomerate offers more difficulties. However, it is believed that their origin is secondary, being the result of some process of solution and substitution of potash feldspar by alkaline or carbonated waters. The fact that foraminiferal tests are found embedded in these nodules and heavily coated by the same calcareous materials which compose the nodules points toward a secondary origin. The extremely hard and limy character of the Mendez immediately beneath the conglomerate suggests, too, that it derived its lime from the decomposition and alteration of the tuff above it. The facts that the nodules are well rounded and that Mendez foraminifera are found in the conglomerate, strongly suggests the action of waves and currents at depths shallow enough for the pebbles to be rolled about and for some slight reworking of the Mendez surface to have taken place. Submarine deposition of the original tuff is indicated by the distribution of this thin bed over an area of at least 800 square kilometers, for otherwise it would probably have been removed by erosion. The presence of this thin bed also shows that if it were exposed at all during the pre-Velasco post-Mendez hiatus, it could have been only a short time for there is no evidence of erosion.

In the area under consideration there could not have been much erosion of the Mendez because, generally speaking, faunas of the same horizon are found underlying the Velasco. However, the fact that there are local erosional unconformities is evidenced by the finding of a long, narrow tongue of Velasco some three and one-half kilometers long by 250 meters wide, with Mendez shale on one side some 200 feet lower stratigraphically than the Mendez on the other side. This condition points to a pre-Velasco fault with the Velasco sea entering the fault depression after some erosion of the Mendez had taken place. Undoubtedly, during the hiatus, there was erosion—possibly submarine erosion—of the Mendez where enough relief existed.

That the early Velasco sea was fluctuating is shown by the character of the life in the peculiar basal stage that has been described. First there is the

conglomerate, which means, if not total emergence, at least a very shallow sea; next comes the shallow water fauna with some sand. Then, with some gradation, appears an almost entirely pelagic fauna which indicates deeper water. This pelagic fauna is followed rather abruptly by a shallow water fauna with considerable sand; the shallow water fauna grades upward into a deep water pelagic fauna (Fig. 1). After initial fluctuations which must have taken place in rather a short time because of the thinness of the lowermost basal stage, the Velasco sea was normally deep. This is shown by the fact that the faunal aspect of the Velasco formation is, in general, dominantly pelagic in type.

LATE PALEOZOIC HOLOTHUROIDEA

CAREY CRONEIS
Walker Museum, University of Chicago, Chicago, Illinois

G. Dallas Hanna, in a recent issue of this *Journal*[1], described and figured a number of minute holothurian plates from Pennsylvanian and Permian strata of Kansas. These interesting calcareous bodies, which were given the name of *Laetmophasma* (?) *kansasensis*, are the first to be described from the late Paleozoic rocks of North America. They have, however, been recorded not only from the Zechstein of Germany by Spandel[2] (as Hanna states), but Etheridge[3] also has described a number of holothurian plates from the Carboniferous rocks of Scotland. In addition, similar if not identical forms have been discovered by Helen Jeanne Plummer in the Pennsylvanian strata of Texas; and they also occur in the Chester series of Illinois, particularly in the Paint Creek, Glen Dean and Renault formations. A paper describing these Texas and Illinois specimens is being prepared by John McCormack and the writer.

It is interesting to note that one of Etheridge's species, *Cheirodota* [sic] ? *traquairii*, is almost certainly identical with Hanna's *Laetmophasma* (?) *kansasensis*. In fact, although Etheridge's material is unavailable, his description and particularly his figure[4] of *C. ? traquairii* might well have been based on the specimens which Hanna illustrated, or for that matter upon some of the specimens from the Chester of Illinois. For this reason Hanna's *L. ? kansasensis* probably should be regarded as a synonym of Etheridge's species.

The generic disposition of this apparently widespread form is a difficult problem. The genus *Laetmophasma* to which Hanna tentatively refers the Kansas material was based by Ludwig[5] upon specimens dredged from depths

[1]Jour. Pal., Vol. 4, p. 413, pl. 40, figs. 1-7, December, 1930.

[2]Abb. Ges. Nat. Hist. Nurnberg, Vol. 11, 1898, pp. 40-45, pl. 13, figs. 9-10.

[3]Proc. Roy. Phys. Soc. Edinburgh, Vol. 6, 1880-81, p. 196, pls. 5-7.

[4]*Op. cit.*, pl. 6, fig. 1.

[5]Mem. Mus. Comp. Zool., Harvard Coll., Vol. 17, No. 3, 1894, pp. 85-95, pls. 10-11.

of 660 to 905 fathoms in eastern Pacific waters off the coast of Central America, and there is at present no other certain record of its occurrence. It is true that wheels illustrated by Hanna are quite similar in appearance to some of Ludwig's specimens, especially his figures 3, 11, 21, 22, and 23, plate 11. Figure 22, however, seems to indicate that the configuration of the central portion of the wheel of the modern *Laetmophasma fecundum* is different from that in the wheels from the Carboniferous of Kansas. In any case, if the Kansas specimens are actually Paleozoic representations of *Laetmophasma*, that genus has since that time changed its habitat from relatively shallow to semi-abysmal depths.

Spandel, Schlumberger, and Etheridge have all referred fossil holothurian spicules to the modern genus *Chiridota*, which is a shallow water form. There is no question but that the wheels described by those authors as well as those illustrated by Hanna have a close resemblance to some modern *Chiridota* plates. But that genus is by definition characterized by wheels which are *six-spoked*, whereas the fossil wheels under discussion all have more than six spokes. The modern shallow-water holothurian, *Caudina*, however, is characterized by calcareous bodies, which in *C. arenata* Gould are very similar to the wheels figured by Hanna. According to Deichmann[1] the deposits of *C. arenata* are "numerous large tables with four cental holes and eight to ten outer holes, margin knobbed." In most of the modern representatives the marginal knobs are somewhat more marked than is the case of the fossil wheels, but Selenka[2] has illustrated a "Kalkkörper" of *C. arenata* from Grand Manan which is essentially identical to those from the late Paleozoic rocks of United States and Great Britain. I therefore suggest that for the present the latter be referred to the genus *Caudina*.

BAIRDIA CORYELLI, A NEW NAME FOR *B. VENTRICOSA* ROTH AND SKINNER

ROBERT ROTH AND JOHN SKINNER
Indian Territory Illuminating Oil Company, Bartlesville, Oklahoma

Dr. H. N. Coryell has called our attention to the fact that *Bairdia ventricosa* Roth and Skinner is preoccupied by *Bairdia ventricosa* Kirkby (1858, Ann. Mag. Nat. Hist., Ser. 3, Vol. 2, p. 326, pl. 10, fig. 3-3a). Therefore, the new specific name *Bairdia coryelli* Roth and Skinner is proposed for *Bairdia ventricosa* Roth and Skinner as described in "The Fauna of the McCoy Formation, Pennsylvanian of Colorado (Jour. Pal., Dec., 1930, Vol. 4, No. 4).

On page 340 of the above Journal, line 6 from the top, read "*Climacammina cushmani* (Harlton)."

[1]Bull. Mus. Comp. Zoöl. Harvard Coll., Vol. 71, No. 3, 1930, p. 201.;

[2]Zeit. Wiss. Zoöl., bd. 17, 1867, pl. 20, fig. 131.

METHODS AND TECHNIQUE

ILLUSTRATING FOSSILS

G. DALLAS HANNA
California Academy of Sciences, San Francisco

In most cases the illustrations which accompany or should accompany papers dealing with fossils can be made of more value to the subsequent user than is the text of the same papers; therefore, it is just as important to prepare and edit the pictures carefully as it is to make correct and concise the language of the text. The following brief notes summarize certain processes, which, it is believed, will enable satisfactory and trustworthy reproductions to be made. This summary is not intended to displace the standard text-books on photography, photomicrography or pencil and pen-and-ink drawing; in fact it is extremely important that those who prepare papers on paleontologic subjects should procure such texts and obtain a working knowledge of the process which he expects to follow in making his pictures.

Most of the information presented pertains primarily to the preparation of illustrations of small fossils which require some magnification although many points are applicable to large forms.

METHODS OF REPRODUCTION

Before beginning the preparation of illustrations for a paper, the author should determine which of the three common processes of printing are to be used in the final publication.

Halftone. A ruled screen is interposed between the original picture and a copper plate in making a halftone block, in order that points may be obtained to hold the printer's ink. The size of the meshes of the screen used determines the minuteness of detail which can be reproduced. In illustrating scientific papers it is customary to use screens having 150 or 175 meshes to the inch and this demands that the printing be done on a grade of paper which has a very

[1]The accompanying notes on the preparation of illustrations of fossils for publication are the result of some years of study of the subject. They were assembled in their present form before I became aware that Doctor Reeside, likewise a close student of such matters, had prepared a paper for the Journal (See September, 1930, number). In the present article I have attacked some of the problems from a slightly different angle and it may appear that at times there is repetition. However, some elementary features of illustration deserve repetition, and in some cases it may happen that Doctor Reeside has given a different process or method for obtaining a given result than the one I have outlined in the following pages; but this only serves to emphasize the complexity of modern commercial art and processes of printing pictures. There are, of course, many important details and methods of procedure which neither of us have mentioned. If our efforts serve to improve the character of the illustrations of the Journal, we shall feel gratified.

smooth surface. This may be readily observed by comparing a halftone of coarse mesh on newspaper stock with one in the Journal of Paleontology (Fig. 1).

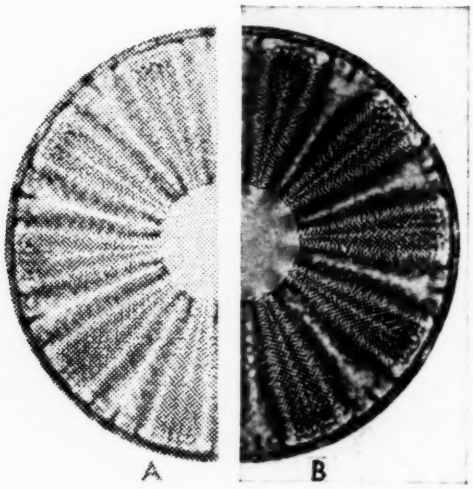


FIG. 1.—*Actinoptychus glabratus* Grunow; × 340±; diameter 0.017 mm. A, Halftone reproduction by means of coarse screen of about the same mesh as is used in newspapers to show loss of detail. Photograph by William M. Grant from specimen from Upper Miocene, near Taft, California. B, Opposite half of photograph shown in A, reproduced by halftone, the screen being that usually employed in scientific illustrations by halftone. Compare plates in the *Journal of Paleontology* up to the September, 1930, number.

It is well known that upon slight magnification, even the halftone picture of finest screen loses its detail and becomes a blur. It is therefore necessary to prepare the original pictures upon such a scale that the finest details desired to be reproduced shall be considerably larger than a single mesh of the halftone screen. If the author has a fossil photographed at an enlargement of 40 diameters and on a print of this scale the sculpture he wishes to show measures 1–150 of an inch in diameter, obviously this cannot be done by means of a 150-mesh screen halftone. It could not even be shown with a 175-mesh screen. A safe rule to follow is to have no desired detail of a picture less than 1–50 of an inch in diameter.

The interposition of the screen plate in making the halftone copper block, produces another very noticeable effect for which there is no perfect correction. Since the screen covers the entire picture the jet blacks of the deepest shadows of the original will reproduce as a dark gray and the chalky whites of the highest highlights of the original will be light gray. In other words, the contrast of the original becomes greatly lessened in the final print. This should always be borne in mind in the preparation of drawings and photographs for halftone reproduction and the originals should be made more contrasty than would

appear correct for a finished picture. A safe rule to follow in practice is to make the deepest shadows of every picture jet black and the highest high lights chalky white. Between the two there should usually be every intergradation of gray. The greatest fault of the average beginner in illustration is that he makes his blacks a dirty gray and over the high lights he puts a wash so that the final printing comes out little better than a smudge. Often he will attempt to make a drawing with a single pencil and that no softer than, say the "H" grade of the "Venus" series.

Zinc Etching. Pictures suitable for reproduction by this process are pen and ink drawings and pencil drawings made on a rough surface, stipple-board paper with a soft carbon pencil. The drawing is photographed upon a zinc plate which is etched to produce a printing surface. No screen is used. Therefore it becomes possible to reproduce such drawings on rough paper as text illustrations. The process has an additional advantage in that it is considerably

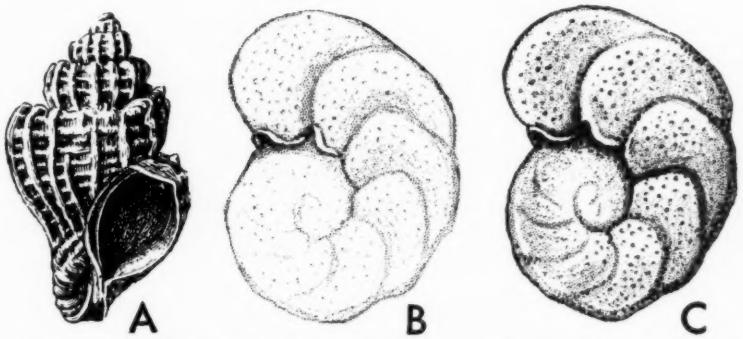


FIG. 2.—A, *Tritonalia painei* Dall; length 15 mm. Reproduced as a zinc etching from a zinc etching which in turn was made from a pen and ink drawing by Dr. J. C. McConnell. After W. H. Dall, U. S. Nat. Mus., Bull. 112, 1921, pl. 6; fig. 1. B, *Planulina ornata* d'Orbigny; × 45 ±; greatest diameter 0.9 mm. Lower Pliocene mud shale from Lomita Quarry, Los Angeles County, California. Reproduced as a zinc etching from a drawing made on No. 1 stipple board by C. C. Church; drawing made with a single pencil, HB grade, to illustrate unsatisfactory result from such procedure. C, *Planulina ornata* d'Orbigny; × 45 ±. Drawing made by C. C. Church from same individual as B, soft black, non-glossy pencils, made for retouching photographic prints, having been used; outline, darkest shadows and markings retouched with India ink.

cheaper than halftone reproduction. Photographs and shaded pencil drawings cannot be reproduced by this means because the gradation of tones offers no suitable points for holding the printing ink on the finished plate.

Photogravure or Gelatin Plate Printing. This process has been used very extensively in Europe and to some extent in America for the reproduction of scientific illustrations. The original picture, whatever may be its form, is photographed upon a gelatin-coated, light-sensitive plate. The sensitizing is done with chromium compounds which so affect the gelatin that it will hold printer's ink in those parts corresponding to the original picture. No screen is used and a smooth glossy finished paper is not required. Exceedingly faithful reproductons of all kinds are thereby produced and the finished print takes

on the appearance of a well done photograph (See plates in recent issues of the Journal). The grain is somewhat larger than that of an ordinary photographic print but even at that the printed illustrations will stand examination under moderate magnification. The preparation of figures to be reproduced by photogravure or photogelatin does not require the employment of excessive contrast. Also, finer details are more faithfully portrayed. The process has undergone many modifications in the hands of various engravers and passes under several trade names such as: heliogravure, rotogravure, heliotype, phototype, photogelatine, calotype, etc.

It is unnecessary to comment upon the methods of reproducing pictures by means of carved wood blocks and drawing on lithographic stone. The last in particular was a wonderful process (as the illustrations in the reports on the Voyage of the *Challenger* and many other old books show) but it does not conform to modern requirements of printers. Also, because fossils are lacking in color of any special importance it is not necessary to consider the methods employed in color printing.

PREPARING ILLUSTRATIONS

For present purposes a picture of a fossil may be considered to be a series of lights and shades so arranged as to convey the same impression to the eye as the object itself. Colors are not involved, black and white being adequate. Pictures are prepared by photography, or drawing, or a combination of the two.

Whatever the means adopted, there is one unalterable rule, according to convention, to be followed in the making of pictures of objects illuminated with reflected light. The primary illumination of the object should come from the upper left hand corner. Non-uniformity in the direction of lighting of objects on a plate is inexcusable. All that is necessary in order to produce the correct result is for the author to orient his specimens properly before making his pictures. *Any picture which does not have the strongest light coming from the upper left hand corner should certainly be discarded and done over.*

Photography. The number of variable factors which enter into the making of a photographic picture is so great that the combinations are almost infinite. The practiced worker understands the principles of primary and secondary illumination of the object to produce the requisite degree of contrast in the detail to be depicted. He understands the working of his optical equipment; the properties of different grades of negative emulsions, plates or films; the effect of the different ingredients entering into the developing and fixing solutions; the properties of various grades of photographic papers, and the needs of the engraver. Obviously much of this information can be gained only by means of long experience and study. However, since almost all paleontologists at one time or another attempt to make their own photographs, a few concrete instructions may aid the beginner in getting a comfortable start. What follows, however, must in no way be considered to furnish the only possible method of handling any given problem; the number of combinations is well nigh endless.

Selection of Specimens. Naturally the careful worker will select for illustrative purposes those specimens which are as nearly perfect as possible. From a photographic standpoint they need to be uniform in color and free from adhering foreign material. Removable stains should be eliminated because they

may give a false impression of relief or obscure certain desired details. Sometimes it is desirable to whiten the objects and this may be effected easily in two ways. A thin layer of ammonium chloride may be deposited on the surface preferably by the process so well described by Moodie,[1] and Bassler,[2] and others. Another and sometimes better method, equally applicable for any color, is to use pigment paints in a first class artist's air brush. Many good illustrators refrain from using such coatings because of the danger of obscuring certain fine details or giving them an unnatural importance. Again, some paleontologists wish to have all stains and defects of a specimen reproduced accurately to aid in subsequent identification.

Orienting the specimen. The need of so placing the specimen that the primary illumination comes from the upper left hand corner in the finished picture cannot be too strongly emphasized. If not too small, the object can be supported on a piece of modeling clay to insure proper orientation being maintained. It may not be desirable that any of the clay show beyond the margins of the fossil. Small objects such as foraminifera are best cemented into the proper position by means of any of the solutions of gums commonly used for this purpose. A convenient one is a weak water solution of gum tragacanth to which a few drops of phenol solution are added.

Because of the ease of regulating tone of backgrounds, most operators prefer to mount the specimen on clear glass and support this some distance in front of or above the background. To obtain the blackest black, silk velvet of this color is very suitable. The distance the object should be above the background depends on the focal length of the lens in use, but in any case it should be beyond the interval of focus. White blotting paper as brilliantly illuminated as possible, produces a suitable white background. The same effect is produced by working over a ground glass which has an incandescent lamp mounted below. Many workers prefer to pay no attention to the background at the time the negative is made but prepare this to suit themselves by a subsequent operation which will be described later.

Illumination. The method of lighting the object to be photographed is of great importance and requires careful study. Daylight is uncertain in intensity and hard to control so that, except for large specimens, artificial illumination is preferred. The contour and details of most objects are best displayed by using oblique rays but the angle to be adopted must vary within certain limits. a range from 10 to 30 degrees from the horizontal will usually be found to be adequate. With larger fossils to be photographed at very low magnification or none at all, there is considerable difficulty in securing an even, diffuse illumination by artificial means; for this reason many workers make use of daylight alone in such cases. It may be noted, however, that commercial photographers who make pictures of objects comparable in size and detail to fossils have elaborate illumination equipment and very rarely use daylight at all.

A single light source may be used with satisfactory results, the primary illumination coming from the upper left hand corner. The secondary illumination

[1]R. L. Moodie, Methods of studying fossil Amphibia embedded in coal. Kansas Univ. Soc. Bull., vol. 9, No. 16, Sept., 1915, pp. 187-193.

[2]Bassler, R. L., Silurian, Md. Geol. Survey.

may then be provided with a reflector placed on the lower right hand side. This reflector may be made of white paper but tin foil is better because it can be bent to any shape and will rest conveniently on the same support as the specimen. The reflector may be shifted so that the secondary illumination lights the deepest shadows sufficiently to show the details and outline of the object.

Some operators prefer to shift the illuminant from the upper left corner after adequate exposure has been given, to the lower right and expose one-half to three-fourths as long. A better way is to provide two lamps, the one on the lower right providing only one-half to three-fourths the intensity of the opposite. For instance, a shell may be properly illuminated by using two lamps of 100 and 75 watts.

In some cases three or more lamps are necessary. Proper precautions should, of course, be taken to shield the lens from any direct rays; otherwise the negative will be fogged. There are many advantages to be gained by doing the work in a dark room but this is not absolutely essential.

When magnification is required the intensity of the illumination must be correspondingly increased to avoid abnormally long exposures. This makes it necessary to provide a condensing lens to concentrate the image of the filament of the lamp on the object. Several forms of lamps are available and very satisfactory; two may be mentioned, the "point-o-lite" and the "ribbon filament." An even concentration of light of great intensity cannot be obtained with an ordinary incandescent lamp. Small arc lights are very satisfactory, but generate considerable heat.

Optical Equipment. A bewildering array of lenses, shutters, microscopes and cameras is available for use in scientific photography and the beginner is utterly unable to make a wise selection. The following notes and suggestions pertain chiefly to principles and equipment that I have found satisfactory but the subject can in no way be considered to be adequately covered here. Likewise, the remarks to follow, as well as some of those above are primarily applicable to the photography of small objects where magnification from ×5 to ×150 is required. Entirely different procedure might be followed in macrophotography.

Unless the objects to be photographed are all approximately the same size, more than one lens will be required and much difficulty is usually experienced in making a proper selection. The following table may be accepted as a rough guide:

Focal length of lens	*Dimensions of objects suitably covered*	*Nature of objects*
2 mm.-4 mm.	.001 mm.- .1 mm.	Diatoms
8 mm.	.1 mm.- .5 mm.	Diatoms
16 mm.	1 mm.- 1.5 mm.	Foraminifera and ostracodes
32 mm.	2 mm.- 4 mm.	Foraminifera and ostracodes
48 mm.	6 mm.-12 mm.	Mollusca, etc.
64 mm.	24 mm.-48 mm.	Mollusca, etc.
100 mm. (4 in.)	100 mm. and up	Mollusca, etc.
150 mm. (6 in.)	100 mm. and up	Mollusca, etc.
250 mm. (10 in.)	100 mm. and up	Mollusca, etc.

Naturally the lens to be used to photograph an object of a given size depends to a great extent on the fineness of detail to be resolved and the initial magnification required. No hard and fast rule can be laid down. It may be stated positively, however, that the greater the magnification required, the shorter must be the focal length of lens used, and the amount of useful magnification obtainable with a given lens depends upon several extremely important optical factors. Among these, first comes the numerical aperture of the lens. The color correction, the spherical correction, the permissible bellows draw, the size of the permissible circle of confusion and the depth of the specimen all enter into the problem and tend to confound the uninitiated. The subject is difficult to explain in simple terms because some fundamental knowledge of optics is requisite to a proper understanding. Take numerical aperture for instance: it is safe to say that very few users of microscopes in our universities and industries have the slightest conception of the meaning of the term, yet it is a fundamental property of lenses. It is the sine of half the angle subtended by the cone of light taken into and through the lens. A thorough understanding of it is absolutely essential in high magnification microscopy if the results are expected to be above the mediocre, and it is of great help in low magnification work. Most of those engaged in the last, do not possess the equipment necessary to determine the numerical aperture of their objectives even if they understood the meaning and importance of the term. Therefore, the following table of useful magnifications is presented. In explanation, it should be stated that numerical aperture increases as focal length decreases and with the very best constructed short-focus lenses the maximum useful magnification in practice is approximately 1,000 times the numerical aperture. By "useful" is meant that enlargement beyond which no additional detail can be resolved and sharpness of detail begins to be lost, because of the size of the circle of confusion. The best constructed of all common lenses are the 2 mm and 3 mm. apochromatic series of several makers, having a numerical aperture of 1.40. The maximum useful magnification ordinarily obtained by such objectives is, therefore, about 1,400 diameters.

Maximum useful magnification obtainable with common lenses

Focal length	*Numerical aperture*	*Theoretical useful magnification*
2 mm.	1.20	1239
3 mm.	1.20	1239
3 mm.	1.40	1330
4 mm.	0.95	902
4 mm.	0.85	807
8 mm.	0.65	617
16 mm.	0.30	284
16 mm.	0.10	94
24 mm.	0.055	52
32 mm.	0.055	52
48 mm.	0.055	52
64 mm.	0.055	52
100 mm. (4 in.)	0.055	52
150 mm. (6 in.)	0.055	52
250 mm. (10 in.)	0.055	52

This table has been computed from the formula $M = 2L \times N.A. \times D$ where M is the magnification desired; L is the wave length of light used (in this case, 1,870 waves to the millimeter = green light); $N. A.$ is the numerical aperture, and D is the permissible diameter of the disk of confusion. The last is the disk of confused light produced by the magnification of a point, and 0.254 mm. is the maximum size most microscopists consider to be permissible.[1]

In making use of the above table several variable factors should be kept in mind. The computation is based on the use of a green ray of light in the middle of the spectrum. If a ray removed toward the red end be used the amount of useful magnification is correspondingly reduced. On the contrary, if the violet end of the spectrum be approached the permissible magnification is increased. This feature will appear more evident upon consultation of a table of light wave units such as the following:

Table of Wave Lengths of Light Rays

Color of Light	*Angström Units (Ten Millionths of a Millimeter)*	*Number of Waves per Millimeter*	*Number of Waves per Inch*
Red	7000	1428	36,271
	6800	1471	37,363
	6600	1515	38,481
	6400	1562	39,674
	6200	1613	40,970
Yellow	6000	1667	42,341
	5800	1724	43,700
Green	5600	1786	45,364
	5400	1852	47,041
	5200	1927	48,956
Blue-Green	5000	2000	50,800
	4800	2084	52,933
Blue	4600	2174	55,219
	4400	2296	58,318
Violet	4200	2381	59,411
	4000	2500	63,500

Obviously L in the formula cited increases toward the violet and this correspondingly increases the maximum useful magnification; or, in other words, finer details can be resolved with a given magnification the closer the light used approaches the violet end of the spectrum.

It should not be assumed that it is never advisable to exceed the magnifications stated in the table. In photography it is sometimes highly desirable to enlarge even the finest resolvable details so that they will show plainly in

[1]See, Spitta, E. J., Microscopy, ed. 3, 1920, pp. 136-141 for an amplification of this subject.

a halftone engraving, or for other reasons; but no such enlargement will disclose any additional structure.

The lenses listed from 16 mm. to 250 mm. focal length are presumed to have been constructed for photography and to have an iris disphragm having a series of "F" numbers. These lenses are ordinarily supplied with a "speed" of F. 4.5, corresponding to a numerical aperture of N. A. = .055 when no magnification or reduction is made. When they are used for magnification the N. A. value is increased in accordance with the data presented in the table below:

The numbers composing the "F" system mentioned are the quotients obtained by dividing the diameter of the iris opening into the focal length of the lens. These "F" numbers may be converted into numerical aperture by means of the following formula,[1] in which M is the magnification and F the number referred to:

$$N.A. = \frac{M}{2F \times (M+1)}$$

When the formula is applied to the "F" numbers usually found on shutters the following table is obtained.

N. A. Values of Photographic Lenses of Various F Stops and Various Magnifications[1]

"F" Values	*Magnification*						
	1	*5*	*10*	*25*	*50*	*75*	*100*
4.5	.055	.092	.10	.10	.10	.10	.11
5.6	.044	.074	.081	.085	.087	.088	.088
8	.031	.052	.056	.060	.061	.061	.061
11	.022	.037	.041	.043	.044	.045	.045
16	.015	.025	.028	.030	.030	.030	.030
22	.011	.019	.020	.021	.022	.022	.022

The apparent increase in numerical aperture which accompanies increase in magnification is associated with the fact that as the image is progressively enlarged, the working distance (between front of lens and object) is shortened.

From what has been given it will be seen that even the fastest camera lenses have a low numerical aperture compared to the better microscopic lenses. Also, it is unlikely that any camera lens is constructed with the exacting care necessary to permit it to be used for as great a magnification as 1,000 times the numerical aperture, although many of the higher grade of microscopic lenses can approach this figure.

Still another difficulty is encountered when attempts are made to use long-focus camera lenses for magnified images. It becomes impracticable to

[1]Hind, H. L. and W. B. Randles. Handbook of photomicrography, 1913, p. 79.

[2]Hanna, G. D. The photography of small objects. Trans. Am. Micr. Soc., vol. 46, 1927, p. 17.

obtain the long extensions of bellows which are necessary. This distance between lens and negative may be computed in advance by means of the following formula: $C = (M+1)F$ where F = focal length and M the magnification. To obtain a magnification of 50 diameters with a 6-inch focal length lens, it would be necessary to employ a bellows draw of 306 inches or 25 feet. Even if it were mechanically practicable to utilize such distances, distortion due to air currents and vibration would be very troublesome.

Theoretically, the depth of focus obtainable with a long-focus and short-focus lens should be the same if the same magnification and numerical aperture are employed. However, the longer working distance of the longer focus lens cuts down the effective numerical aperture and there is apparently a greater depth of focus with a correspondingly poorer resolution of details. The most experienced operators generally select a lens for a particular object of such a focal length that the field of view is only two to three times greater than the diameter of the object. They obtain the required depth of focus as nearly as may be possible by the regulation of the iris disphragm.

For this purpose many low power combinations suitable for use on a microscope stand, are constructed with a diaphragm between the component elements of the objective. These lenses may be obtained with focal lengths varying from 16 mm. to 64 mm. and for the objects to which they are suited they are generally preferred. For higher magnification, there is available an iris diaphragm mounted in a short tube so threaded that it will fit into the barrel of a microscope and also take the usual objectives.

The choice of oculars to be used with a given lens requires some consideration. For all achromatic objectives and the small photomicrographic lenses mentioned, the common Huygens ocular is best and should be employed providing the requisite magnification cannot be obtained otherwise without an undue camera extension. An ordinary aplanatic hand magnifier is preferred by some to any ocular.

When apochromatic objectives are employed, they must be accompanied by compensating oculars in order to complete the corrections of the lens system; the best image cannot otherwise be obtained. One manufacturer has recently put on the market a separate series of oculars designed exclusively for photomicrographic purposes. They are normally used with magnifications greater than 300 diameters.

Since this article is prepared primarily for the reader who is interested in the photography of small fossils but not those which are extremely minute, only general information will be given for work with diatoms and objects of similar size. Photographing them presupposes a thorough knowledge of the operation of a compound microscope. This instrument happens to be the most convenient piece of apparatus available, even for low power photographs, although the substage portion of the instrument is not used with reflected illumination. The convenience is largely due to the excellent means made available for fine focusing. The size of object which can be photographed with a compound microscope stand varies from the smallest up to approximately 30 mm. in diameter. The upper limit is set by the length of the rack by means of which the lens and body tube are elevated above the object.

A microscope having a body tube of large diameter is preferable because it is then easier to eliminate internal reflection. Great care must be taken in this respect and any side wall reflections must be blocked out completely either with black paper or metal diaphragms or by making all the interior of the tube dead black by some suitable means. A lining of black silk velvet is often recommended for the purpose.

Whether an ocular be used or not the connection between the microscope and camera must be made light tight.[1] Cameras made for the purpose are provided with the necessary metal sleeves for this but a suitable substitute may be easily improvised out of soft leather. No camera lens need be used, the image from the microscope being projected directly on the plate or film.

Many forms of cameras are available, horizontal and vertical. No recommendation as to make will be specified, but for all ordinary low power work the vertical camera is certainly most convenient to use. The stage of the microscope can thereby be left horizontal and the object is much more easily illuminated.

My own preference is for a vertical camera with a heavy base plate and the standard upon which the camera slides adjustable to any angle from horizontal to vertical. The upright is graduated in millimeters, the length being about 600 mm. The microscope is placed on the base plate and adjusted centrally with the camera. Such equipment is usually furnished to take plate holders 4×5 inches but if the work be done in a dark room these can be eliminated to advantage. In the position normally occupied by the plate holder, a heavy cardboard is placed and in practice a series of these is provided. Central openings are cut in these supports of variable shape and size. When the picture is made, the negative is placed emulsion side down over the opening of the support.

For focusing the image, two pieces of glass must be provided, one clear and the other ground. These are placed over the opening with the ground glass on top. A rough focus is obtained and the illumination and orientation of the specimen carefully studied and adjusted. The finer focus is obtained on the clear glass alone. Some scratches are made on the lower side of this and these are brought into accurate focus by a lens which is made especially for this purpose, a focusing glass. Obviously if the image of the object be exactly focused at the same time as the scratches on the clear glass, the negative will likewise be in focus when placed in the same plane.

Photographic material and technique. Plates or films may be used. The former will lie flat on the support that has been described without weighting but the latter should be held down flat by means of a heavy black cardboard or similar object. Many workers prefer negatives prepared with an emulsion known as "Process" or "Process Panchromatic." Both have a very fine grain and normally possess much contrast. If the camera be equipped with a negative support as indicated, cut films may be obtained in large size and divided

[1]Very satisfactory photomicrographs many be made without light-tight connection between ocular and camera, providing the camera lens, focused at ∞, is mounted just above the ocular. The Leica camera is very useful in this way.—Editor

into any smaller units required. Some saving in cost of film is thereby effected. The choice of negative emulsion is a matter which requires some study and experiment. The two mentioned are intrinsically very contrasty and it is obvious that if the object be illuminated in a contrasty manner this is accentuated on the plate. Some modification can be effected in the developer but for small objects contrastly illuminated with condensers, I prefer a soft working plate, such as "standard orthonon." There is scarcely a statement which can be made in this connection which may not be challenged. Experience alone is the best teacher.

Most lenses work best with light which is limited to a small portion of the visible spectrum. It is therefore desirable to use color screens whenever practicable. These have been so standardized that almost any portion of the spectrum can be eliminated at will. But for photomicrographic purposes where fossils are concerned, three screens will usually suffice. Those especially recommended are green, blue and violet and are sold under the trade designations B, C, and D respectively. Since the wave-length transmitted with the D (violet) screen is the shortest of the three, the greatest resolution can be obtained with light of this color. The eye is more sensitive to green, however, and consequently the image is more easily focused with this color. Of course the negative should be made with light of the same color that is used for focusing.

The time of exposure is dependent upon the color of the specimen, intensity of illumination, numerical aperture and magnification. Therefore, no rules can be formulated. A series of test exposures must be made. It is most convenient to regulate the illumination so that an exposure of fifteen to sixty seconds is required because thereby the need of a shutter on the camera is obviated. The exposure may be timed with the electric switch, and the intensity of illumination may be placed under control by having a rheostat in the lighting circuit.

After the negative is exposed it may be developed in any one of a multitude of solutions all possessing somewhat different properties and producing some variation in the tones of the printed picture. The most commonly used agents are metol, hydrochinon and pyrogallic acid. The first two have the desirable property that solutions prepared with them keep unaltered for considerable periods of time. A further disadvantage of pyro is its tendency to stain the gelatin emulsion yellowish brown; in spite of these features many operators use it exclusively.

It must be borne in mind that the degree of contrast in a negative is governed by three factors only: (1) the character of the emulsion, (2) the character of the illumination, (3) the composition of the developer. The beginner in photography of fossils is advised to keep the first constant, that is, use a single brand of plate or film; that known as "Process" has already been suggested. The only alternative I would make in beginning would be to use "Standard Orthonon" emulsion and then only if the illumination be extremely contrasty. The character of the illumination may likewise be kept approximately constant, at least for experimental purposes. The high lights must not be too brilliantly illuminated and the shadows must not be too dark. Experience alone will show how these should be balanced. By using differing proportions of metol and

hydrochinon in the developer a great range of contrast is obtainable when the other two factors are kept constant.

The maximum degree of contrast is obtained by using a straight hydrochinon developer to which some potassium or ammonium bromide has been added. Needless to say this would not be permissible for paleontological work; however, it is extremely useful for copying printed matter or line drawings. The addition of a larger and larger proportion of metol with reduction of hydrochinon and bromide will lessen the contrast obtained and some such combination is that usually required for pictures of fossils. The following formula (or any desirable fraction of all ingredients) has proved satisfactory for much work and may be adopted safely as a starting point:

Water (125° F.)	64 ounces
Metol (or Elon)	60 grains
Sodium sulphite	3¼ ounces
Hydrochinon	1¼ ounces
Sodium carbonate	3¼ ounces
Potassium bromide	¾ ounce
Water to make	1 gallon solution

This must not be considered a recommendation as a universal developer; there is no such thing. Furthermore, too much emphasis cannot be placed on the desirability of learning the properties of the various chemicals used in developing because once this has been mastered a much better result can be obtained under a given set of conditions.

Very often the photographer will adopt a special brand of developer which comes already weighed out ready to mix with a stated amount of water. In the absence of any knowledge of the chemistry of photography this is perhaps the best procedure but is not to be recommended for other than the amateur. The temperature of any developing solution plays an important rôle and a metol-hydrochinon solution should be held within the range of 65°-70° F.

Sodium thiosulphite (hypo) is used to dissolve that portion of the silver salt from the negative which has not been acted upon by light and consequently has not been developed. Full directions for compounding the solution may be found in most packages of plates or films. A hypo solution made with chrome alum as the hardening agent is preferred by many commercial photographers.

Directions for washing and drying the negative, preparatory to printing are readily accessible.

Choosing a suitable paper upon which to make the positive print from the negative requires careful study. There are so many brands and grades on the market and the properties are so variable that the beginner must be greatly confused. A few points may be mentioned, however, which should help in making a selection.

Halftone engravers prefer that the print be made on glossy paper, properly dried on a ferrotype plate. This may be accepted as general practice for all prints which do not require retouching. Glossy paper suitable for printing by exposure to an ordinary electric light may be obtained in at least four grades of contrast and it is desirable to have all four on hand. Naturally the most contrasty grade will be used with the least contrasty negative and vice versa.

When the prints must be retouched, a smooth non-glossy surface should be chosen and again several grades of contrast should be provided if possible. This great variation in the properties of paper obtainable makes it possible to do most printing with a single developing solution, and the solution selected should be that recommended by the manufacturer of the paper unless there be some good reason for not doing so.

Often it is desirable to do a certain amount of retouching on the negative. This particularly obtains in the case of backgrounds which are desired to be white on the final print. Often it is necessary to block out the background to accomplish this. A red "opaque" is provided by several manufacturers expressly for this. It comes in the form of a cream in jars or collapsible tubes and needs thinning with water before being applied to the emulsion side of the negative. A brush is usually used for this purpose but the outline of the object may be traced with a pen. India ink is not suitable for such work because it cracks upon drying. A deep ruby red dye is provided for the same purpose and has some advantages over opaque. It is sold under the name "Neococcin." This dye in a dillute condition may be used to paint a thin wash over the deepest shadows of the image (the lightest parts on the negative) to hold them back from becoming black in the print while adequate exposure is given to the highlights.

Attention is also called to a method of blocking out the background of a negative by the use of thin ruby-red cellophane, such as is used for wrapping candies and cakes. A sheet of this is fastened to the negative on the emulsion side by moistening the latter with water in a few places, outside of the image. The cellophane is pressed into contact with a roller after which a sharp knife may be used to cut around the margin of the image.[1]

A practiced worker can use negative retouching pencils and delicate knives to modify the shading and sharpen details and outlines on the negative but this requires considerable skill. It is perhaps better to do such work on the print with pencils and brush. Ordinary lead pencils are not well suited to this purpose because of the gloss they leave on the part of the print worked upon. It is much better to procure pencils made especially for positive retouching by several manufacturers. Work done with these pencils is without gloss. Three or four grades of hardness should be provided. A paper or leather stomp may be used to smooth down the pencil grain so that it blends perfectly with the photographic image. Some retouchers prefer to use a brush with water-soluble color. Such "spotting colors," fixed dry on convenient cards are distributed by photographic dealers. Black, sepia and white are the usual colors. The white is used to lighten certain parts of the picture which are printed too dark and also to intensify the whitest highlights.

PEN AND INK DRAWING

Having had some slight experience in this form of scientific illustrating, my advice to the person desiring to use pen and ink is to take an example of one of the masters of the process, enlarge it about three times photographically

[1]See Mann, Albert. Blocking out undesirable backgrounds in photographs. Science, N. S. vol. 70, No. 1817, Oct. 25, 1929, p. 408.

and then endeavor to copy it as perfectly as possible. A long period of disappointing experiment will thereby be largely eliminated. The most skilful artist who has used the process for fossils was undoubtedly Dr. J. C. McConnell, who drew incomparable pictures of shells for many years. His drawings mostly appeared in the publications of the U. S. Geological Survey and the U. S. National Museum. An average specimen is reproduced herewith to illustrate the process.

Such drawings are almost always reproduced from a zinc etching and can be printed readily on ordinary text paper. In order to smooth out the imperfections of lines and dots, the drawing should be made at least double the size of the desired print, the reduction being effected by the engraver. Obviously a fine-pointed pen is necessary but it should be rather stiff. Some artists prefer to grind the points themselves on a hone under a microscope. The ordinary india ink used by draftsmen is satisfactory. In order to make it flow freely, it is often diluted with a small quantity of ammonia water but this should not be carried so far that the lines appear brown instead of black. Dots such are used in stipple work are best made with the pen held vertical; the pen points usually need grinding on a hone to insure that a perfectly circular spot of ink is left each time.

It will be noticed in examining Dr. McConnell's work that his shading varies from very black in the deepest shadows to pure white in the highlights. This, and the rule regarding direction of illumination should always be adhered to strictly.

Paper suitable for pen and ink drawing can be obtained from dealers in artists' supplies. Its chief essentials are that it be of smooth surface and free of loose fibers or other material which will be picked up by the pen and cause a smudgy line.

Extremely beautiful effects can be obtained by means of pen and ink in scientific illustration. The one serious objection to it lies in the fact that the lines and dots used for showing light and shade may be confused with fine details of the object. And, of course, there is the objection which applies to all drawings and retouched photographs: at best they are diagrams showing someone's conception of the forms and details of objects. The backgrounds of pen and ink drawings should remain white.

PENCIL DRAWING

The use of pencils for making drawings of fossils dates back to the days of stone engraving and is still one of the most important means of delineation. To meet the needs of the modern halftone engraver certain rules and specifications should be adhered to rather rigorously. Drawings need not be made larger than the reproductions are expected to be; slight reduction, however, say one-half or one-third may help to smooth out irregularities in the pictures.

The paper upon which the work is to be done needs to be white in color but the roughness of the surface varies with the preference of the artist. Usually, however, a smooth surface gives the best results and permits the indication of finer detail.

The selection of pencils is somewhat difficult, but if those recommended for retouching photographic prints be employed, excellent results may be obtained. The so-called "carbon" pencils are probably best because of the blackness of the powdered "lead." Several grades of hardness should be provided in order to obtain proper gradation of tones. The grain of the pencil shading should be obliterated by means of a paper or leather stomp. To get sharp lines the pencils should be kept sharp with sandpaper or otherwise. The deepest shadows should be made black, not gray, and only the highest highlights should be left white. Between the two there should be the gradation of tone disclosed by the properly lighted object. One of the best modern exponents of such pencil drawing is Miss Margaret S. Moore, of Sharon, Mass.; an example of her work is shown herewith.

There is still another method of pencil drawing which should be given consideration; this is the use of stipple board paper. This paper is mechanically surfaced into a series of minutely raised points or beads, uniformly spaced. A soft black pencil is used for the shading and the darker tones are produced by greater pressure producing larger dots. Sharp outlines are difficult to get with a pencil on stipple board, so these are usually made with pen and ink. Also some India ink stippling in the darkest shadows may improve the result. Such drawings are usually reproduced as zinc etchings and consequently they should be made about twice as large as they are to be printed. Good examples of this style of drawing may be found in Mrs. Helen Plummer's paper on the Midway foraminifera of Texas.[1]

Some paleontologists prefer to have the backgrounds of photographs and pencil drawings white. Methods of treatment of the negative for this purpose have already been described. Whatever method is used, it will be necessary to have the engraver "tool" out the copper plate to the margins of the pictures; otherwise even the whitest of white backgrounds will appear light gray on the printed plate.

To obviate this tooling and also to produce an effect which is pleasing and desirable in many ways, a jet black background may be provided. There are several ways to obtain such a result. Objects to be photographed may be so mounted that the background of the negative will be perfectly clear, and that of the print therefrom, jet black. If this has not been done, or if drawings are desired to be blocked out with black, the color is painted on. Some engravers object to India ink for this purpose because of its "gloss;" a water soluble black used by air brush operators is very satisfactory. Often the pictures are mounted on optically black cardboard which is obtainable from paper dealers. Whatever the mount may be, the edges of the photographs and drawings should be blackened, as well as the background.

Numbers may be lettered on the plates but usually these do not appear as neat as those printed from type. The latter can be obtained, printed on gummed paper and of any size desired. I have had considerable difficulty securing these with the numbers in white on a black background. They can be made photographically by printing or having printed, the series of numbers of the size

[1]Helen Jeanne Plummer, Foraminifera of the Midway formation in Texas. Univ. Texas Bull. 2644, 1926, pp. 1-206, 15 pls.

desired on a piece of thin transparent film. The numbers should be printed as black as possible. This film may then be used as a negative and photographic prints made therefrom should be satisfactory.

However pencil drawings are made they should be protected from rubbing; they must necessarily be subjected to considerable handling before the final printing plate is completed. The usual practice is to spray the copy with a solution of white shellac in alcohol. The clear liquid from the top of a bottle in which this varnish is stored is best and dealers in artists' supplies furnish such a "fixative." Also a simple atomizer tube for producing the spray can be obtained. I have tried a weak solution of Dupont Household cement in amyl acetate and also in the "thinner" which is supplied with the cement and this preparation seems very satisfactory. It has the advantage of being colorless, tough, flexible and moisture proof.

USE OF CAMERA LUCIDA

Almost all drawings of fossils are most expeditiously made by means of a camera lucida or some apparatus whereby the image of the object is projected upon the paper. The first usually is placed over the ocular of the microscope or takes the place of the ocular; however, it can be obtained for drawing macroscopic objects where no microscope is used. In either case a prism or mirror is provided whereby the eye sees the pencil and paper at the same time as the object. It is necessary to so regulate the illumination of the two that the one does not completely blot out the other. Disks of plain smoked glass are provided with most instruments to aid in obtaining this equalization of illumination but often it is more convenient to do this by means of a piece of cardboard used to cast a shadow on object or paper. In this manner it is possible to bring pencil and object alternately into very sharp view and the outline of the object may be traced exactly. If a compound microscope be used in a vertical position the drawing paper may be placed horizontally on the table beside it, but if an instrument with an inclined tube, such as one barrel of a binocular be used, it is necessary to tip the drawing board with the paper atttached, to approximately the same angle as the inclination of the optical beam. The stage supporting the object should likewise be tipped so that it is at right angles to the optical axis of the tube used. A supplemental stage should be provided for this purpose. Stage and drawing paper should be parallel.

MEASUREMENT OF SPECIMENS

The accurate measurement of specimens illustrated and the computation of the scale of magnification of the published figures are extremely important and seem to have been overlooked in some cases. Therefore, it is believed that a careful consideration of these two phases of illustrating is in order.

The measurement of large objects, that is, from 10 mm. up, can best be done with a beam caliper equipped with a vernier which reads to .1 mm. Such instruments are obtainable from tool manufacturers. Objects smaller than 10 mm. should be measured through a microscope of suitable power and for this some special equipment is necessary. It is not sufficient to place the specimen on a millimeter scale and estimate the fractions, particularly for such

fossils as foraminifera, ostracodes and those smaller. The best method of measuring these will be considered first and alternative methods later.

A stage micrometer should be provided; the common ones are ruled on glass with intervals of .01 mm. The place of the eyepiece is taken by a filar micrometer which is graduated and provided with movable cross-hairs. The various objectives used for measuring must be calibrated as a preliminary procedure. This is done by observing the number of divisions of the filar

---

EXPLANATION OF PLATE 8

FIGS. 1.—*Globigerina bulloides* d'Orbigny; vertical dimension 0.65 mm. Photogelatin reproduction from photograph of specimen from Pliocene, Los Angeles County, California. Great difficulty is experienced in securing adequate depth of focus with lenses of sufficient numerical aperture to resolve the details of such forms as this. The details here are too small to reproduce well and when enlarged from the negative (fig. 3) the sharpness is considerably impaired. 1A, Same, negative enlarged to × 80±. Note the imperfect sharpness of the details and the dark gray—not black—background.

2.—*Globigerina bulloides* d'Orbigny; same as fig. 1 but taken with aperture too wide open; note the very slight depth of focus obtained.

3.—*Uvigerina pygmaea* d'Orbigny; × 27.5±, length 0.73 mm. Photogelatin reproduction of photograph of specimen from Pliocene, Los Angeles County, California. Because of the coarseness of the markings on this form it is possible to resolve the details clearly and at the same time keep the object in satisfactory focus by closing the iris diaphragm. The background, obtained photographically is not a deep enough black.

4.—*Uvigerina proboscidea* Schwager; × 35±, length 0.82 mm. Reproduction from photograph. Lens used was entirely unsuited, having too little numerical aperture to resolve the details of the spines and the "disk of confusion" is much larger than 0.254 mm. Specimen from the Pliocene of Los Angeles County, California. The object was wrongly oriented so that the picture had to be inverted to have the primary illumination right. Results such as this are not uncommon in photographing foraminifera.

5.—*Planulina ornata* d'Orbigny; × 26.5±; greatest diameter 0.73. Reproduction from photograph of specimen from Pliocene, Los Angeles County, California. Such a flat form stays in focus well so that lenses of large numerical aperture can be used. Details are slightly too small for best reproduction; see fig. 8.

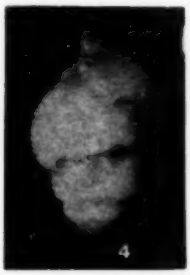
6.—*Planulina ornata* d'Orbigny; same as fig. 5; negative enlarged to × 60± to display characters shown in finer markings. Background obtained photographically is not a deep enough black.

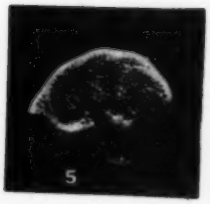
7.—*Clathurella paupercula* (Gabb); length 8.5 mm. Example of retouched photograph by Miss Helen Winchester. This picture was obtained by photographing the halftone printed by H. A. Pilsby, Proc. Acad. Nat. Sci. Philadeplhia, 1921 (1922), pl. 18, fig. 4; details are not as sharply defined as if the original drawing had been used.

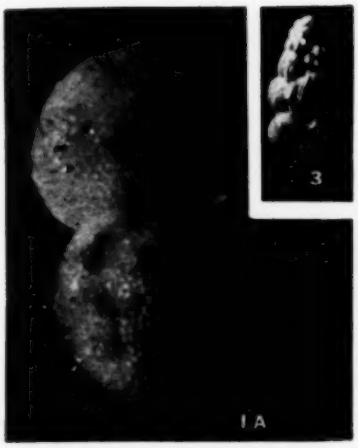
8-10.—*Planulina ariminensis* d'Orbigny; × 64±. Photogelatin reproductions of pencil drawings of specimen from Rimini, Italy; See: J. A. Cushman Contr. Cushman Lab. Foram. Res., Vol. 5, pt. 4, 1929, p. 102, pl. 15, figs. 4a-c. These are excellent examples of the use of black pencils for shading; the drawings were made by Miss Margaret S. Moore. Background painted black.

1

2

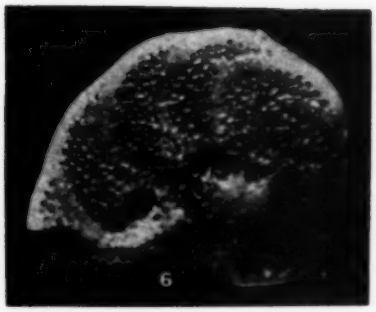

4

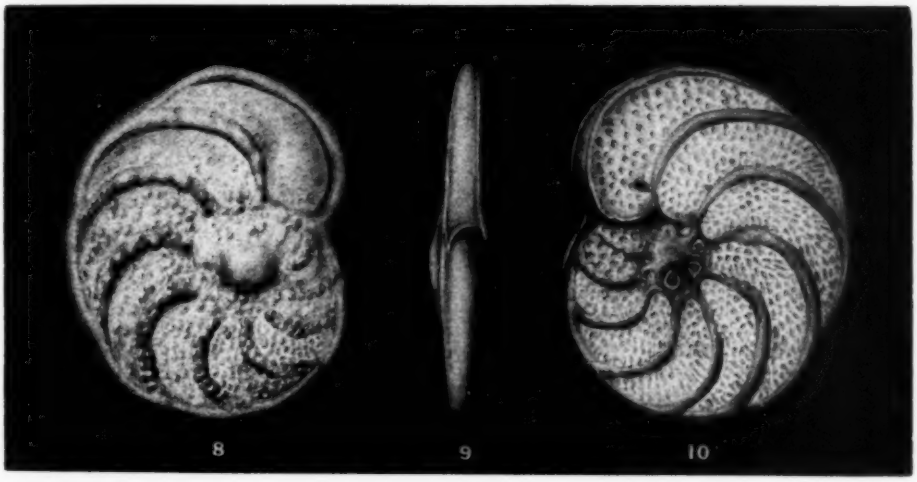

5


1A

3

7


6


8
9
10

micrometer required to span some interval of the stage micrometer, say 1 mm. This observation is repeated several times with each objective to insure accuracy and a table is made for subsequent use.

Suppose for illustration that 1 mm. of the stage micrometer is spanned with 100 divisions on the drum of the filar micrometer, when a 16 mm. objective is being used. If a specimen be substituted for the stage micrometer and its length is 76 divisions on the drum, the actual length is 76 ÷ 100 or .76 mm.

Once the lenses used are calibrated this does not need to be done again unless by some chance the distance between objective lens and filar micrometer becomes altered. When a compound microscope is being used for measurement, it is of the utmost importance that the same tube length be strictly adhered to for measurement and calibration. Otherwise an entirely erroneous result will be obtained.

For low magnification measurement, what is called an ocular micrometer is often used. This is a disk of glass of the right size to be dropped in the barrel of an ocular to rest on the diaphragm. The glass is ruled with some parallel lines, an arbitrary distance apart. Of course this instrument must be calibrated for each objective in precisely the same manner as has been described for the filar micrometer. Great care must be exercised that the ocular disk is always used with the same ocular; otherwise the results will be erroneous. If more than one ocular must be used, then separate tables of calibration must be prepared for each lens combination employed. Obviously, the ocular micrometer is far less accurate than the filar because the fractions of intervals between the rulings must be estimated whereas with the latter they are actually measured. In high-power work it is extremely easy to measure objects with the filar micrometer with an error of not more than .0001 mm.

Another method of measurement is by means of a camera lucida which is normally used to outline microscopic objects for drawing. The method is simply to replace the object, after the outline has been made, with a millimeter scale and mark on the paper the positions of the lines bounding one or more intervals. If the interval marked be 1 mm. then the length of the magnified image of the interval represents the magnification. If then the length of the outlined image of the object be measured and this divided by the magnification, the actual length of the specimen will have been obtained, subject to the following errors. The chief source of error in this method lies in the inability of the operator to determine accurately the magnified interval; the width of the division marks on the scale is usually too great. The error can be overcome to a certain degree by averaging several measurements. Another source of error lies in the impracticability of placing the scale in the exact plane occupied by the object. If any change of focus be required at this instance, the distance from the camera lucida to the paper is changed and the magnification of scale and object will not be the same. These details should be carefully observed by any one attempting to use this method.

However accurately photographs, drawings and measurements of specimens may be made, it is not likely that the published print will have exactly the same magnification computation. It has often been suggested that a

uniform scale of magnification be adopted for publication but this is not exactly practicable as will be shortly explained. Some such series as the following would be excellent if it could be adhered to rigidly:

× 1; × 2; × 3; × 4; × 5; × 7.5; × 10; × 15; × 20; × 25;
× 30; × 40; × 50; × 75; × 100; × 150; × 200; × 300;
× 400; × 500; × 750; × 1000; × 1500.

The labor attached to getting the original drawings or photographs to any of these arbitrary figures with exactness is enormous. For instance, suppose two objects are desired to be photographed at exactly ×50. It might be supposed that this could be simply accomplished by placing a millimeter scale on the stage of the microscope and extending the bellows so that in the image on the ground glass 1 mm. ×50 mm.; then the object is substituted for the scale and the photograph is made. But the image of the object will not be ×50 unless by chance not the slightest alteration in focus is required and this is extremely remote. The thickness of the scale must then be adjusted until the plane of the divisions comes precisely in the plane of the object and this is far from easy unless the stage of the microscope be provided with an adjustment for focusing, independently of the body tube; (some excellent microscopes are so made). But for the sake of illustration, suppose that the image of the first object is made to be exactly ×50. If any adjustment in the focus of the instrument is required for the second object, its image will not be ×50 and the entire procedure must be repeated. Obviously such an expenditure of time is impracticable and the errors in our publications bear out the statements made.

Probably not more than one percent of the indicated magnifications are correct. Part of the final error often comes when the engraver makes the plate He must rephotograph the original picture and his difficulties in getting exactly ×1 or ×½ etc. are just as great as those of the original operator.

The correct way to get the times magnification of a printed picture is first: Procure an accurate measurement of the original object, as by the filar micrometer method. Second: divide this into the corresponding measurement obtained from the printed picture on the proof sheets, not on the original drawing or photograph. In order that the user of the publication may check the computation readily, it is highly desirable that in the explanation of plates or figures there shall be given at least one of the important dimensions of the original object and this to be accompanied by a statement of the times enlarged. If the latter is obtained only approximately, that fact should be so stated.

SOCIETY RECORDS AND ACTIVITIES

MEMBERS OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

ADAMS, JOHN EMERY, Box 578, Midland, Texas
ADKINS, WALTER SCOTT, Bureau of Economic Geology, Austin, Texas
ALEXANDER, C. I., Texas Christian University, Box 192, Fort Worth, Texas
ANDERSON, CARL B., 941 Kennedy Bldg., Tulsa, Oklahoma
ANDERSON, FRANK MARION, 58 Hillcrest Road, Berkeley, California
APPLIN, MRS. ESTHER R., 2200 Edwin Avenue, Fort Worth, Texas
ARICK, MILLARD B., Humble Oil & Refining Company, McCamey, Texas
ATCHISON, JAMES W., Pure Oil Company, Fort Worth, Texas
ATHY, L. F., Marland Production Company, Ponca City, Oklahoma
BAKER, CHARLES L., 535 Commercial Bank Bldg., Houston, Texas
BAKER, WILLIAM A., JR., Geological Department, Cia. de Petroleo Mercedes, S. A., Apartado 269, Monterrey, N. L., Mexico
*BALL, JOHN RICE, 2305 Sherman Avenue, Evanston, Illinois
BANKS, THOMAS R., 1003 Fourth Street, Corpus Christi, Texas
BARBAT, WILLIAM F., Standard Oil Co., Bin XX, Taft, California
BARTLETT, CHARLES L., Sun Oil Co., Beaumont, Texas
BARTON, DONALD C., 717 Petroleum Bldg., Houston, Texas
BAUERNSCHMIDT, A. J., JR., Union Sulphur Company, Sulphur, Louisiana
BELL, FRANK W., 2724 Parkway, Bakersfield, California
BELL, OLIN G., P. O. Box 548, Laredo, Texas
BENEDUM, DARWIN, 414 W. Elsmere Place, San Antonio, Texas
BERNOULLI, DR. W., 77 Steinengraben, Basle, Switzerland
BINGMAN, NEAL J., California Company, Box 578, Midland, Texas
BOHART, M. F., 2301 Irwin Street, Fort Worth, Texas
BOWSER, W. F., Arkansas Fuel Oil Co., Box 341, San Angelo, Texas
BRADFIELD, HERBERT H., Shell Petroleum Corporation, Oklahoma City, Oklahoma
BRADISH, FORD, 1205 W. T. Waggoner Bldg., Fort Worth, Texas
BRANSON, E. B., Department of Geology, Missouri University, Columbia, Missouri
BREHM, RALPH CARL, Box 1484, Tulsa, Oklahoma
BRIDGE JOSIAH, 35 Poplar Street, Takoma Park, Washington, D. C.
BULLARD, FRED MASON, Geological Department, University of Texas, Austin, Texas
BURCKHARDT, CARLOS, General Leon 60, Tacubaya, Mexico, D. F.
CAHILL, EDGAR D., Skelly Oil Company, 510 Ellis-Singleton Bldg., Wichita, Kansas

*Associate members. Distinction between full and associate members is drawn on the basis of membership in the American Association of Petroleum Geologists, of which the Society is a division, associate members of the Society not being members of the Association.

CAMPBELL, ROBERT B., 2119 Alamo National Bldg., San Antonio, Texas
*CANFIELD, CHARLES R., 1925 W. 43rd Street, Los Angeles, California
CANNON, R. L., 510 San Angelo National Bank Bldg., San Angelo, Texas
CARTWRIGHT, LON D., JR., 408 Rust Bldg., San Angelo, Texas
CHENEY, M. G., P. O. Box 446, Coleman, Texas
CHURCH, CLIFFORD C., 79 New Montgomery Street., San Francisco, California
CLARK, BRUCE L., Geology Department, University of California, Berkeley, California
COCHRAN, PHIL K., Carter Oil Co., 810 Central Bldg., Wichita, Kansas
COLE, W. STORRS, Sun Oil Co., First National Bank Bldg., Room 417, Dallas, Texas
*COOPER, G. ARTHUR, U. S. National Museum, Washington, D. C.
CORYELL, HORACE N., Columbia University, New York City
COX, BEN BURTON, Room 417, 26 Broadway, New York City
CRAM, IRA HIGGINS, 1408 South Indianapolis, Tulsa, Oklahoma
CRONEIS, CAREY G., Walker Museum, University of Chicago, Chicago, Illinois
CRUSE, JOHN S., JR., The Pure Oil Company, Houston, Texas
CUSHMAN, J. A., 76 Brook Road, Sharon, Massachusetts
CUYLER, ROBERT, 1216 West 22nd Street, Austin, Texas
DAMON, H. GORDON, Department of Geology, University of Iowa, Iowa City, Iowa
DECKER, CHARLES E., 508 Chautauqua Avenue, University of Oklahoma, Norman, Oklahoma
DELO, DAVID M., Geology Department, Northwestern University, Evanston, Illinois
DEWOLF, F. W., Louisiana Land & Development Company, 1704 Esperson Bldg., Houston, Texas
DEUSSEN, ALEXANDER, 1606 Post Dispatch Bldg., Houston, Texas
DOANE, GEORGE H., Pacific Western Oil Company, Room 604, 1709 W. 8th Street, Los Angeles, California
DODSON, FLOYD C., Ricker & Dodson, 24½ South Chadbourne, San Angelo, Texas
DORR, JAMES BRYAN, Huasteca Petroleum Company, Apartado 94, Tampico, Tamps., Mexico
DOTT, ROBERT H., Sunray Oil Corporation, Philcade Bldg., Tulsa, Okla.
DRIVER, HERSCHEL L., 630 W. Palm Drive, Glendale, California
*DUNBAR, CARL O., Peabody Museum, Yale University, New Haven, Connecticut
EDWARDS, EVERETT C., 1227 Viscaino Drive, Glendale, California
*EIFLER, GUS K., 4008 Avenue F, Austin, Texas
ELLISOR, ALVA C., Humble Oil & Refining Company, P. O. Drawer D, Houston, Texas
FEAGIN, BARNEY, 1122 East 20th Street, Tulsa, Oklahoma
FLETCHER, CORBIN D., P. O. Box 673, Meridian, Mississippi
FOSTER, FRED KLEBER, Box 675, San Angelo, Texas
GALLOWAY, ALAN J., Shell Oil Company, 100 Bush Street, San Francisco, California
GALLOWAY, JESSE J., Columbia University, New York City

GARDNER, JULIA, Geological Survey, Washington, D. C.
GIERHART, GUY BALCER, P. O. Box 548, Laredo, Texas
GILBOE, JOHN D., 2216 Parkway, Bakersfield, California
GILES, ALBERT W., Geology Department, University of Arkansas, Fayetteville, Arkansas
GLENN, LEONIDAS C., Vanderbilt University, Nashville, Tennessee
GORDON, WALLACE, 1130 Milam Bldg., San Antonio, Texas
GOUDKOFF, PAUL P., 1204 Subway Terminal Bldg., Los Angeles, California
*GRANT, U. S., IV, Box 396, Beverley Hills, California
GRAVELL, DONALD W., 1901 Huldy Street, Houston, Texas
GREEN, GUY E., Vacuum Oil Company, San Angelo, Texas
GREENE, FRANK C., 1434 S. Cincinnati Avenue, Tulsa, Oklahoma
GRIM, RALPH E., Department of Geology, State University of Iowa, Iowa City, Iowa
HAIGHT, HAROLD W., McAllen, Texas
HAMILL, JAMES M., 129 N. Brighton, Burbank, California
HANNA, G. DALLAS, California Academy ofSciences, San Francisco, California
HANNA, MARCUS A., P. O. Drawer C, Houston, Texas
HARRIS, REGINALD W., Geology Department, Oklahoma State University, Norman, Oklahoma
HARLTON, BRUCEH., P. O. Box 2022, Amerada Petroleum Corporation, Tulsa, Oklahoma
HAWKINS, GLEN D., The Carter Oil Company, Box 2045, Tulsa, Oklahoma
*HAWKINS, HAROLD H., Department of Geology, University of Kansas, Lawrence, Kansas
*HENDERSON, JUNIUS, 1305 Euclid Avenue, Boulder, Colorado
HEDBERG, HOLLIS D., Apartado 234, Venezuela Gulf Oil Company, Maracaibo, Venezuela
HENDERSON, MRS. DOSKA M., 123 N. Edgemont, Loz Angeles, California
HODSON, FLOYD, Standard Oil Company of Venezuela, Apartado 85, Maracaibo, Venezuela
HODSON, HELEN K., Standard Oil Company of Venezuela, Apartado 85, Maracaibo, Venezuela
HOLLAND, L. F. S., Placerville, California
*HOLLISTER, HAROLD A., 504 78th Street, Wauwatosa, Wisconsin
HONESS, CHARLES W., Gypsy Oil Company, Geology Department, Tulsa, Oklahoma
*HORNBERGER, JOSEPH, JR., Swenson Oil and Gas Co, Inc., Stamford, Texas
HOWE, HENRY V., Louisiana State University, Baton Rouge, Louisiana
*HOWELL, B. F., Department of Geology, Princeton University, Princeton, New Jersey
HUDNALL, JAMES SHARON, Coleman, Texas
HUGHES, DONALD D., 929 South Broadway, Texas Company, Los Angeles, California
HUTCHESON, R. B., 2285 Eucalyptus, Long Beach, California
HUTSON, E. B., Standard Oil Company of Louisiana, Shreveport, Louisiana
ISRAELSKY, MERLE C., United Gas Corporation, P. O. Box 1760, Houston, Texas

JOHNSON, J. HARLAN, P. O. Box 343, Golden, Colorado
*JURIN, VLADIMIR N., 122 S. Benton Way, Los Angeles, California
KAUFMANN, GODFREY F., Cia de Petroleum Mercedes, S. A., Apartado 269, Monterrey, N. L., Mexico
KAY, G. MARSHALL, Department of Geology, Columbia University, New York City
*KELLETT, BETTY, Amerada Petroleum Corporation, P.O. Box 995, Wichita, Kansas
KELLEY, HOWARD A., 1944 Milan Avenue, South Pasadena, California
*KEMP, AUGUSTA HASSLOCK, Seymour Public Schools, Seymour, Texas
KEYTE, I. A., Colorado College, Colorado Springs, Colorado
KING, PHILIP B., U. S. Geological Survey, Washington, D. C.
KING, ROBERT EVANS, The Texas Company, 135 East 42nd Street, New York City
KNIKER, HEDWIG T., Phillips Petroleum Company, San Angelo, Texas
*KNIGHT, J. BROOKES, Peabody Museum, Yale University, New Haven Connecticutt
KOCH, RICHARD E., 9, Hegenheimerstrasse, Basel, Switzerland
KORNFELD, M. M., Atlantic Oil Producing Company, D06 Central Bldg. Wichita, Kansas
*KUFFEL, GEORGE C., 319 West 23rd Street, Long Beach, California
LAIMING, BORIS G., The Texas Company, Room 307, 929 South Broadway, Los Angeles, California
LANG, W. B., U. S. Geological Survey, Roswell, New Mexico
LLOYD, E. RUSSELL, Box 776, Midland, Texas
LINK, THEODORE A., Geological Department, Imperial Oil Company, 606 Second Street W., Calgary, Alberta, Canada
LOEL, WAYNE, 812 Subway Terminal, Los Angeles, California
*LOHMAN, KENNETH E.; 455 S. Hill Avenue, Pasadena, California
MACKENZIE, ANDREW N., Apure-Venezuela Petroleum Corporation, Apartado 683, Caracas, Venezuela, S. A.
MACNAUGHTON, LEWIS W., 1718 Milam Bldg., San Antonio, Texas
MADDOX, GERALD C., 2112 North Villa, Oklahoma City, Oklahoma
MAUCINI, JOSEPH J., Continental Oil Co., Hamilton Bldg., Wichita Falls, Texas
MAY, ARTHUR R., 405 Haberfelde Bldg., Bakersfield, California
MCCLELLAN, HUGH, Box 262, Burke-Greis Company, Tulsa, Oklahoma
MCCLUNG, ESTHER C., 145 Louise Street, Atlanta, Texas
MCCOY, ALEX, Royalty Bldg., Ponca City, Oklahoma
MCLAREN, ROBERT LEE, 1415 Washington, Golden, Colorado
MILLER, JOHN CUMMINS, The Texas Company, Houston, Texas
*MINTON, J. W., Sun Oil Company, 417 First National Bank Bldg., Dallas, Texas
MONSOUR, ELI THOMAS, Apartado 269, Monterrey, N. L., Mexico
MOORE, RAYMOND C., University of Kansas, Lawrence, Kansas
MOREMAN, W. L., Department of Geology, Texas Christian University, Fort Worth, Texas
MORGAN, FRANK A., 855 Subway Terminal, Los Angeles, California

MORRISON, T. E., Humble Oil & Refining Company, Nixon Bldg., Corpus Christi, Texas
*MOSS, R. G., Department of Geology, University of Kansas, Lawrence, Kansas
MOSSOM, STUART, 1630 Rosewood Avenue, San Antonio, Texas
MYERS, JOHN CLARK, Box 1865, Shell Petroleum Corporation, Houston, Texas
*NEWELL, NORMAN D., 308 West 12th Street, Lawrence, Kansas
*NEWMAN, GRACE, 532 Commercial Bank Bldg., Houston, Texas
NEWMAN, THOMAS F., Skelly Oil Company, Tulsa, Oklahoma
NIGHTINGALE, WILLIAM T., Mountain Fuel Supply Company, Rock Springs, Wyoming
NOMLAND, J. O., Standard Oil Company of California, Standard Oil Bldg., San Francisco, California
NORTON, R. D., Box 1737, Texas Company, Shreveport, Louisiana
NUTTALL, W. L. F., Apartado 150, Tampico, Tamps., Mexico
OLDHAM, ALBERT E., Louisiana Oil Refining Company, Shreveport, Louisiana
OLSSON, WXEL A., 48 Woodside Avenue, Gloversville, New York
OWENS, FRITH CRAVENS, Box 787, McAllen, Texas
*PALMER, MRS. KATHERINE V. W., Paleontological Laboratory, Cornell University, Ithaca, New York
PETTY, DABNEY E., 10 Tenth Street, San Antonio, Texas
PFANNKUCHE, MRS. H. C., Pure Oil Company, Fort Worth, Texas
PLUMMER, F. B., Bureau of Economic Geology, University of Texas, Austin, Texas
PONTON, GERALD M., 319 South Woodward Avenue, Tallahassee, Florida
PORCH, EDWIN L. JR., Box 573, San Antonio, Texas
PRICE, W. ARMSTRONG, P. O. Box 112, Corpus Christi, Texas
RANKIN, WILBUR D'ARCY, Continental Oil Company, 202 Medico Dental Bldg., Los Angeles, California
REED, RALPH D., 1110 Glendon Way, South Pasadena, California
REESIDE, JOHN B., JR., P. O. Box 175, Hyattsville, Maryland
REIGLE, E. E., Box 577, Seminole, Oklahoma
REITER, WILHELM A., Mexia, Texas
RICE, ELMER M., Pure Oil Company, Petroleum Bldg., Fort Worth, Texas
RICHARDS, J. T., 901 Petroleum Bldg., Oklahoma City, Oklahoma
RIDINGS, LOWELL J., Mexican Sinclair Petroleum Corporation, Tampico, Tamps., Mexico
*RIES, MINETTE, Phillips Petroleum Company, San Angelo, Texas
ROGATZ, HENRY, Phillips Petroleum Company, Amarillo, Texas
RIGGS, ROBERT J., Drawer L, Bartlesville, Oklahoma
ROLSCHAUSEN, F. W., 903 Humble Bldg., Humble Oil & Refining Company, Houston, Texas
ROOK, STEPHEN H., Division Paleontologist, Box 1731, Shreveport, Louisiana
ROSS, CLARENCE S., U. S. Geological Survey, Washington, D. C.
ROTH, ROBERT, Indian Territory Illuminating Oils, Geological Department, Bartlesville, Oklahoma
ROUNDY, PAUL V., U. S. Geological Survey, Washington, D. C.
RYAN, RUSSELL, Vacuum Oil Company, Esperson Bldg., Houston, Texas
RYNIKER, CHARLES, Gypsy Oil Co., P. O. Box 2044, Tulsa, Oklahoma

SAMPLE, HURST, Livingston Hall, Columbia University, New York City
SAMUELL, JOHN HOWARD, Box 652, Coleman, Texas
SANDIDGE, JOHN R., Geology Department, Princeton University, Princeton, New Jersey
SARGENT, ELWOOD CATHER, Bureau of Economic Geology, Austin, Texas
*SAVAGE, T. E., 613 West Nevada Street, Urbana, Illinois
SCHENK, HUBERT GREGORY, Box 1583, Stanford University, California
SCHUCHERT, CHARLES, Peabody Museum, New Haven, Connecticut
SCOTT, GAYLE, Texas Christian University, Fort Worth, Texas
SELIG, A. L., Box 898, Fort Worth, Texas
SELLARDS, ELIAS H., Bureau of Economic Geology, Austin, Texas
SIDWELL, RAYMOND, Geology Department, Texas Technological College, Lubbock, Texas
SIEGFUS, STANLEY S., Haberfelde Bldg., Bakersfield, California
†SMITH, JAMES PERRIN, Leland-Stanford University, Leland Stanford, California
SMITH, WAYNE M., 608 East Church Street, Santa Maria, California
SNIDER, LUTHER C., Henry L. Doherty & Company, 60 Wall Street, New York, New York
SPENCER, MARIA, Superior Oil Co., San Angelo, Texas
SPIEKER, EDMUND M., Orton Hall, Ohio State University, Columbus, Ohio
STAINBROOK, M. A., Department of Geology, Texas Technological College, Lubbock, Texas
STANGLE, FRANK J., JR., Dixie Oil Company, San Angelo, Texas
STAUFFER, CLINTON R., Department of Geology, University of Minnesota, Minneapolis, Minnesota
*STENZEL, HENRYK B., Department of Geology, A. & M. College, College Station, Texas
STEPHENSON, DR. LLOYD W., U. S. Geological Survey, Washington, D. C.
TATUM, EMMETT P., JR., 903 Humble Bldg., Houston, Texas
TESTER, ALLEN C., Old Science Bldg., Iowa City, Iowa
THALMANN, HANS E., Schwarztorstr. 22, Berne, Switzerland
THOMAS, NORMAN L., Pure Oil Company, 912 Petroleum Bldg., Fort Worth, Texas
THOMPSON, CHARLES L., P. O. Box 997, Eastland, Texas
THOMPSON, S. A., Vacuum Oil Company, Esperson Bldg., Houston, Texas
TIEJE, ARTHUR J., 2016 S. La Salle Avenue, Los Angeles, California
TOMLINSON, CHARLES W., 610 Simpson Bldg., Ardmore, Oklahoma
TRAGER, EARL A., Skelly Oil Company, Tulsa, Oklahoma
TRASK, PARKER D., Prospect Apartments, Princeton, New Jersey
TROWBRIDGE, A. C., University of Iowa, Iowa City, Iowa
TWENHOFEL, W. H., University of Wisconsin, Madison, Wisconsin
UDDEN, J. A., 801 W. 31st Street, Austin, Texas
UPP, JERRY E., Box 2007, Tulsa, Oklahoma
UPSON, MERLIN E., Gulf Production Company, P. O. Box 737, Fort Worth, Texas

†Deceased.

VANDERPOOL, H. C., Box 1817, Houston, Texas
VAUGHAN, T. WAYLAND, Scripps Institution, La Jolla, California
WALDSCHMIDT, W. A., Midwest Refining Company, Box 240, Denver, Colorado
WARTHIN, ALDRED S., JR., Geological Department, Vassar College, Poughkeepsie, New York
WATERS, JAMES ALTON, Sun Oil Company, Dallas, Texas
*WEBB, JAMES A., 609 E. Elmira, San Antonio, Texas
WELLER, J. MARVIN, State Geological Survey Division, Urbana, Illinois
*WELLS, JOHN WEST, Box 1686 University Station, Austin, Texas
WANDER, WILLIAM G., Box 638, Cisco, Texas
WEYMOUTH, ANDREW ALLEN, P. O. Box 2410, Denver, Colorado
WHITE, MAYNARD PRESSLEY, Gypsy Oil Company, Ardmore, Oklahoma
WHITNEY, F. L., 4310 Avenue H, Austin, Texas
*WILLARD, BRADFORD, Pennsylvania Topog. & Geol. Survey, Harrisburg, Pennsylvania
WILLIAMS, GARNET A., 844 Kennedy Bldg., Tulsa, Okla.
WINTON, WILL M., Texas Christian University, Fort Worth, Texas
WISSLER, STANLEY G., Box F, Compton, California
*WOMACK, BRAME, 902 Monnett, Norman, Oklahoma
WOODFORD, ALFRED O., Pomona College, Claremont, California
*WOODRING, WENDELL PHILLIPS, U. S. Geological Survey, Washington, D. C.
YOUNG, KARL E., Union Sulphur Company, Sulphur, Louisiana

APPLICANTS

BOSWELL, P. G. H., Imperial College of Science & Technology, London, S. W., England
BROKAW, J. M., Pure Oil Company, Rust Bldg., San Angelo, Texas
HAMILTON, C. E., Wirt Franklin Petroleum Corporation, 702 Franklin Bldg., Oklahoma City, Oklahoma
HORTON, HAROLD M., 548 Park Street, Santa Paula, California
KINDLE, EDWARD M., Victoria Memorial Museum, Ottawa, Canada
MACFADYEN, W. A., Longships, Capel-le-Ferne, Folkstone, England
MCGEE, MARY KATHRYN, 2263 W. 24th Street, Los Angeles, California
MILNER, H. B., 4 Wycombe Gardens, Golders Green, London, N. W. 11, England
MORROW, A. LYNDON, 933 Rhode Island Street, Lawrence, Kansas
PENTLAND, ARTHUR, University of Wisconsin, Madison, Wisconsin
SKINNER, JOHN W., 723 Jennings, Bartlesville, Oklahoma
TAYLOR, W. HARLAN, 624 Lasuen, Stanford University, California
TYLER, STANLEY A, North Dakota Agricultural College, Fargo, North Dakota
WEAVER, CHARLES E., Department of Geology, University of Washington, Seattle, Washington

AMONG PALEONTOLOGISTS

J. J. GALLOWAY of Columbia University has just returned to New York after six months spent in Oklahoma in research on the Fusulinidae of that state. He was on sabbatical leave from the University, and did the work in coöperation with the Gypsy Oil Company, working with Dr. M. P. White and Dr. Charles Ryniker.

J. HARLAN JOHNSON of the Colorado School of Mines, Golden, has a complete set of Professional Papers of the U. S. Geological Survey numbers 1-140 substantially bound in 43 volumes. He can be persuaded to part with them for a consideration.

Among members of the Society of Economic Paleontologists and Mineralogists who attended meetings of the Paleontological Society at Toronto, Canada, December 29-31, are JOSHUA W. BEEDE, HORACE N. CORYELL, DAVID M. DELO, J. J. GALLOWAY, L. C. GLENN, G. MARSHALL KAY, RAYMOND C. MOORE, F. B. PLUMMER, JOHN B. REESIDE, JR., JOHN R. SANDIDGE, E. H. SELLARDS, EDMUND J. SPIEKER, ALLEN C. TESTER, PARKER D. TRASK, J. MARVIN WELLER, JOHN R. BALL, J. BROOKES KNIGHT, B. F. HOWELL, LYNDON MORROW, and W. H. TWENHOFEL. The paleontological meetings were well attended and an interesting program was offered. Papers offered by some of our members include: B. F. Howell, "Cambrian 'Paradoxides' fauna of northwestern Vermont;" J. R. Ball, "A faunal list of the type section of the Bainbridge limestone, Missouri;" F. B. Plummer and Gayle Scott, "Importance of the evolution of certain ammonoid genera in Pennsylvanian and Permian stratigraphy;" Gayle Scott and F. B. Plummer, "Evolution of the family Prolecanitidae in the North Texas Pennsylvanian;" and J. Brookes Knight, "The genus *Soleniscus* Meek." W. H. Twenhofel delivered his presidential address on the subject "Environmental significance of sediments" to a large audience in a joint meeting of the Paleontological Society and the Geological Society of America.

ABRAM O. THOMAS, professor of paleontology at the University of Iowa, and for twenty-two years a member of the faculty of that University, died on January 13th of this year. Few men are privileged to win the admiration and affection in which Professor Thomas was held by his students, the high regard and strong friendship of scientific colleagues who knew him most intimately, and the general esteem in which he was held by the profession. Many members of this Society became acquainted with Professor Thomas on field excursions of the Kansas Geological Society which he attended and to which he contributed greatly. The paper on Devonian foraminifera from Iowa which appears in this issue of the *Journal of Paleontology* is one of the last contributions from Thomas's pen, completed just before the severe illness that led to his death.

A report of the retirement of Dr. E. O. ULRICH, paleontologist plenipotentiary and stratigrapher extraordinary, of the U. S. Geological Survey, which appeared in the last number of the *Journal*, was grossly exaggerated. We are happy to learn that an indefinite extension of the age limit has been granted to Doctor Ulrich; not that "retirement" would have made any difference to a scientist like Ulrich who isn't content with six days a week but tries to crowd eight into seven. Doctor Ulrich celebrated his 74th birthday February 1st; he has been engaged continuously in paleontologic and stratigraphic studies of the Paleozoic rocks for more than 54 years and has been a geologist of the U. S. Geological Survey for some 34 years. It is safe to say that this American paleontologist has many more facts about fossils and sedimentary formations stowed away in his head than any living man. A Scotchman says "May ye live 'till a dead horse kicks ye, an' when he kicks ye may he miss ye."

ALLEN C. TESTER reports completion of the splendid new laboratory of sedimentation and sedimentary petrology at the University of Iowa. Commodious rooms are fitted for various types of analytical and experimental work, and for storage of collections. A good deal of specially designed furniture and apparatus is provided.

WENDELL P. WOODRING has returned from field work in California to Washington, D. C. After some years as a teacher at the California Institute of Technology he is re-establishing himself in congenial surroundings at the National Museum.

COURTNEY WERNER, professor of paleontology at Washington University, St. Louis, has returned from a year's leave of absence during which he completed requirements for the Doctor's degree at George Washington University. He spent the summer abroad.

H. B. STENZEL, of Texas Agricultural and Mechanical College, has a fine collection of lower Eocene crabs collected near Agricultural College, and is engaged in the painstaking work of preparing and studying them.

F. L. WHITNEY, of the University of Texas, and some of his students are engaged in studies on Glenrose faunas.

The University of Toronto has a splendid paleontological museum which is largely the work of Professor W. A. PARKS. The collection of North American and foreign invertebrates and of Mesozoic reptiles from the west are exceptionally good. Paleontologists who attended the Toronto meetings enjoyed these exhibits.

M. K. ELIAS, of the Kansas Geological Survey, has recently completed a study of the fossil seeds of Tertiary grasses, collected in western Kansas.

A new type of binocular microscope with inclined oculars, the stage remaining horizontal, is announced by the E. Leitz Company. Detailed information concerning it is given in their pamphlet 1180.

At a recent meeting of the Fort Worth section of the Society of Economic Paleontologists and Mineralogists MRS. PAUL APPLIN was elected President, and A. L. SELIG was made vice-president.

Wednesday evening, January 14th, E. RUSSELL LLOYD read a paper before the Fort Worth Geological Society, assembled in the Brite College Auditorium at Texas Christian University. His subject was: "Barrier Reefs and Saline Residues in the Permian Basin of West Texas and Southeastern New Mexico."

W. J. WELLS, of the University of Texas is making a study of the Cretaceous corals of Texas. He has available a large personal collection, the collections from the University of Texas, the Bureau of Economic Geology of Texas, Texas Christian University and others.

GLEN JEPSEN, of Princeton University, and C. I. ALEXANDER, of Texas Christian University will spend a part of next summer exploring the ash beds of the Big Bend district of Texas. They hope to find vertebrate fossils.